DOCUMENT RESUME

ED 034 700

SE 007 842

TITLE	Science Grade 9. Curriculum Bulletin, 1968-69 Series, No. 9.
INSTITUTION	New York City Board of Education, Brooklyn, N.Y. Bureau of Curriculum Development.
PUB DATE	69
NOTE	329p.
AVAILABLE FROM	New York City Board of Education, Publications Sales Office, 110 Livingston Street, Brooklyn, New York 11201 ($5.00)
EDRS PRICE	EDRS Price MF-$1.25 HC Not Available from EDRS.
DESCRIPTORS	Curriculum, *General Science, Grade 9, Instructional Materials, Reference Materials, Science Activities, *Secondary School Science, *Teaching Guides
IDENTIFIERS	Board of Education, Bureau of Curriculum Development, New York City

ABSTRACT

This publication is a teacher's guide for teaching ninth grade science in New York City Public Schools. Activities for four areas -- physics, chemistry, earth science and biology -- are included. Five years of experimentation under classroom conditions preceded the publication of this guide which is specifically designed to meet the needs of students of varying abilities. The activities represent a segment of a sequential, concept-oriented K-12 science curriculum for the New York City schools. In accordance with the stated objectives, a specific format is used throughout the guides. Special features of the format are: topical outline; sequential units in each of four science areas; outcomes listed for each lesson; logically developed classroom lessons with specific content, methodology and techniques; designated laboratory lessons including explanatory notes for the teacher and work sheets for the pupils; enrichment materials, such as assignments, questions, reports, and projects. (BR)

N-X

ED034700

SCIENCE

Grade 9

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

SE 007 842

BUREAU OF CURRICULUM DEVELOPMENT
BOARD OF EDUCATION • CITY OF NEW YORK

Permission to reproduce this copyrighted work has been granted to the Educational Resources Information Center (ERIC) and to the organization operating under contract with the U.S. Office of Education to reproduce documents included in the ERIC system by means of microfiche only, but this right is not conferred to any users of the microfiche received from the ERIC Document Reproduction Service. Further reproduction of any part requires permission of the Board of Education of the City of New York.

New York City public schools should order additional copies of this publication from the Bureau of Supplies. Curriculum Publications List No. 00-8040-80.

Copies of this publication may be purchased by outside agencies from: Board of Education of the City of New York, Publications Sales Office, 110 Livingston Street, Brooklyn, N. Y. 11201. Checks should be made payable to: Auditor, Board of Education.

Price: $5.00

ED034700

Curriculum Bulletin • 1968-69 Series • No. 9

SCIENCE

Grade 9

Bureau of Curriculum Development
Board of Education • City of New York

BOARD OF EDUCATION

JOHN DOAR, *President*

REV. MILTON A. GALAMISON, *Vice-President*

JOSEPH G. BARKAN
AARON BROWN
MRS. ANA A. CONIGLIARO
WILLIAM F. HADDAD
MORRIS IUSHEWITZ
JOHN H. LOTZ
ERNEST R. MINOTT
NORMAN REDLICH
MRS. ROSE SHAPIRO
WALTER W. STRALEY
HECTOR I. VAZQUEZ

Superintendent of Schools

BERNARD E. DONOVAN

Executive Deputy Superintendent of Schools

NATHAN BROWN

Deputy Superintendent of Schools

FREDERICK W. HILL
BUSINESS AFFAIRS

THEODORE H. LANG
PERSONNEL

SEELIG LESTER
INSTRUCTIONAL SERVICES

"PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL BY MICROFICHE ONLY HAS BEEN GRANTED BY NYC Board of Education TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE U. S. OFFICE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER."

COPYRIGHT 1969

BY THE BOARD OF EDUCATION OF THE CITY OF NEW YORK

Application for permission to reprint any section of this material should be made to the Superintendent of Schools, 110 Livingston Street, Brooklyn, N. Y. 11201. Reprint of any section of this material shall carry the line, "Reprinted from (title of publication) by permission of the Board of Education of the City of New York."

FOREWORD

In these times of great scientific advancement and opportunity, we are increasingly dependent upon a scientifically literate population. Our young people must be led to explore, to search for, to discover, and to understand scientific ideas which will meet the needs of people in a changing world.

The new science course of study for grades 7, 8, and 9 is part of a K-12 sequential science program. It is based upon the sequential development of scientific concepts from four major science areas.

This bulletin represents a revision of grade 9 science based upon five years of careful experimentation under classroom conditions. It is designed specifically to meet the needs of students of varying abilities.

The science program, of which this bulletin is a part, envisions in-service training in schools and districts.

The Office of Science Education, under the leadership of Samuel Schenberg, Director, is to be congratulated on its pioneering efforts to provide a unique science course of study for youngsters in the intermediate-junior high schools in a large urban community.

SEELIG LESTER
Deputy Superintendent of Schools

September 1968

ACKNOWLEDGMENTS

In June 1961, the Curriculum Council approved the curriculum project for *Science: Grades 7-8-9.* The planning and design of each year of the science project were under the direct supervision of William H. Bristow, Assistant Superintendent, Bureau of Curriculum Development; Martha Finkler, Acting Associate Superintendent, Office of Junior High Schools; and Samuel Schenberg, Director of Science.

To explore the various problems involved in the preparation of a new course of study ("Long" and "Short" form) for the junior high school segment of the K-12 science program, curriculum committees were established. The contributions and expertise of the members are gratefully acknowledged.

Samuel Schenberg, Director of Science, the director of the project, provided the leadership and coordination for committees and individuals involved in the project.

The members of the committee for the "Short Form" were:

Alfred W. Leichtman, Acting Assistant Director, Science, *Chairman* of the Revision Committee
Charles A. Colman, Principal, PS 29X
Ronald Dermer, Teacher of Earth Science, Lafayette HS
Peter Greenleaf, Supervisor, Bureau of Audio-Visual Instruction
George Kanstroom, Chairman, Science, Richmond Hill HS
Leon L. Kurtz, Assistant Principal, JHS 143X
Arthur H. Lefgren, Chairman, Technical Division, George Westinghouse Vocational and Technical HS
William Poppel, Principal, PS 99X
Marie A. Soscie, Teach of Earth Science, Newton HS
Eugene Stern, Chairman, Science Department, George Washington HS
Stanley R. Wachs, Assistant Professor of Science, New York University
Louis Weiss, Chairman, Chemistry and Biology Department, Brooklyn Technical HS

To enrich the instructional program for the inner-city youngster, the "Long Form" for grade 9 was developed in 1966. Members of the writing committee were:

Harold J. Horn, Chairman of Science, William H. Taft HS, *Chairman*
William Altfeld, Teacher, Chemistry, New York School of Printing
Constantine Constant, Teacher, General Science, JHS 217Q
Janis M. Eltz, Teacher, Reading, Reading Center, JHS 136K
Mary Gavin, Teacher, General Science, JHS 17M
Milton Goldberg, Teacher, General Science, JHS 49K
John Hodnett, Teacher, General Science, JHS 190Q
Morris Kluger, Teacher, Physics, James Madison HS
Max Kobre, Teacher, General Science, JHS 117X
Alan Winkler, Teacher, General Science, JHS 278K

This publication, following the pattern established for grade 8, combines the "Short" and "Long" forms into an integrated teacher's guide to meet the needs of all students.

Staff members from the Office of Intergroup Education, the Bureau of Curriculum Development, and the Office of Science Education concluded that the study of science could make a positive contribution toward better human relations and understanding. To implement this decision, two staff members of the Office of Intergroup Education were included in this revision committee working during the summer of 1968:

Sam Fried, Assistant Director of Science, *Chairman*
Leonard Bernstein, Teacher, JHS 120M
Martin Bloom, Assistant Principal, JHS 258K, assigned-Office of Science Education
Kenneth R. Chevers, Teacher, IS 88M, assigned — Office of Intergroup Education
Ronald Dermer, Teacher, Lafayette HS
Harry E. Eisenson, Teacher, assigned — Office of Intergroup Education
Martin Schacter, Chairman of Science, JHS 139M
Lillian Silverman, Chairman of Science, JHS 136M
Alan Winkler, Teacher, JHS 278K
Stanley Wolfe, Teacher, JHS 118M
John Zawasky, Teacher, IS 218K

The contribution of individuals associated with the project are gratefully acknowledged. Members of the staff of the Office of Intergroup Education, Frederick H. Williams, Assistant Superintendent; Bureau of Curriculum Development — David A. Abramson, Acting

Director; Daniel A. Salmon, Acting Assistant Director; Alfred W. Leichtman, Curriculum Coordinator for Intermediate and Junior High Schools; Office of Science Education, Sam Fried, Assistant Director, for his wholehearted cooperation; and Martin Bloom, Assistant Principal, for his supervision and detailed analysis of the feedback.

Staff members of the Bureau of Curriculum Development who were involved in the production of this bulletin are: Aaron N. Slotkin, Editor; Lillian Amdur, edited the manuscript; Eleanor Shea and Elena Lucchini, second editing; Simon Shulman designed the cover; and Elena Lucchini was responsible for the layout and most of the illustrations.

CONTENTS

INTRODUCTION ix

Unit I: PHYSICS xix
Sound 1
Light 31
Unit Review 66
References 70

Unit II: CHEMISTRY 71
Metals 72
Formulas 93
Reactions of Metals 102
Activity of Metals 119
Unit Review 137
References 141

Unit III: EARTH SCIENCE 143
Astronomy 144
Solar System 158
Energy in the Solar System 170
Man and Space 203
Unit Review 216
References 220

Unit IV: BIOLOGY 223
Asexual Reproduction 224
Sexual Reproduction 243
Heredity 289
Unit Review 305
References 308

Introduction

In this publication, *Science: Grade 9,* the "Short" and "Long" forms have been combined and revised, following the pattern established for grade 8. It offers the teacher an integrated guide to meet the varied needs of the students. It constitutes an important segment in a sequential K-12 science curriculum which has been planned for the New York City schools.

Originally, the program for each of the grades (7, 8, and 9) was prepared in two parts for experimental purposes. The first was designated "Short Form" for the youngster who was able to read at his grade level or better; the second, "Long Form" was designed specifically to meet the needs of the inner-city youngster who read poorly (two or three years below grade level).

The design of the program is directed toward meeting the need for a scientifically literate population in this age of rapid technological advances. The pupils are challenged to explore scientific ideas and their applications. In this way, those who find the search for and discovery of ideas exciting and rewarding will be encouraged to prepare themselves for further work in the areas of science.

In harmony with the objective of scientific literacy, a set of basic experiences for which all pupils are responsible form the nucleus of this program. Objects in the environment with which pupils are familiar are often used for further study. New ideas, laboratory skills, and science vocabulary are introduced at a pace which permits easy assimilation. Understandings and interrelationships are constantly reinforced through frequent referral to previous studies. In addition, for those pupils whose interest and abilities warrant, the lessons provide opportunities (italicized) for greater in-depth study.

The science fields are particularly fine areas for experimentation because they allow an unlimited source of self-motivating experiences upon which a high degree of understanding can be built. The study of science enables the teacher to meet the student on common ground.

Science materials and equipment are colorful, interesting, challenging, stimulating, and available on all levels. The science classroom provides an environment in which the youngster can observe and experiment with materials to solve problems meaningful to him.

Innovations, described more fully in following pages, have been introduced for the first time. One is the "Review and Reinforcement" lesson with suggestions and guidelines for extended explorations. Another developed with the Office of Intergroup Education, is the inclusion of materials which are specifically designed to encourage understanding among the different races in an urban community.

OBJECTIVES

The objectives of the junior high school science course of study reinforce the aims of general education and seek to have the pupil continue to:

- develop the concepts, skills, knowledges, and attitudes which were begun in grades K-6
- develop a firm scientific foundation, including laboratory skills, upon which the program in grades 10-12 can be built
- explore the various scientific disciplines for the development of individual interests and abilities
- explore the possibility of a satisfying and challenging career in a scientific field
- understand science as a unified whole by perceiving interrelationships among the four fields of science
- appreciate the role of science in the progress of civilization and in the development of our technological society
- understand the methods employed by the scientist in attacking problems affecting our health and welfare
- apply scientific methods and attitudes, where possible, as a way life.

INNOVATIONS

To attain the stated goals, the program offers up-to-date content in a well-developed matrix that should be interesting and exciting to teachers and students. It progresses logically and in detail to assist and direct new teachers by delineating methodology and techniques in developing units of classroom and laboratory lessons.

Courses, customarily, were designed with the needs of the academically-oriented student at the core. A sizable group of students (20-25%), however, have not been successful in competing and maintaining pace. These youngsters read two, three, and more years below their grade level with the resulting lack of interest. In this group may be found many students of high potential, yet they constitute the underachievers and provide most of the dropouts. This science course of study represents an important educational and experimental approach by the New York City Board of Education to the solution of a national problem.

This manual is so structured that small but highly motivated segments of material are covered over a longer period of time, thus meeting the needs of the slow student and the underachievers. By virtue of the combined basic and enriched lesson, the laboratory lesson, and the review and reinforcement lesson, the students investigate meaningful science problems in small steps but to the same depth required of the bright and average students, thus bridging the gap toward academic success.

To achieve these aims, the following innovations have been introduced:

EMPHASIS ON CONCEPTS. The understanding of important concepts underlying each of the four science disciplines, as well as the interrelationships, are stressed. Biology concepts are treated in greater depth because they are based on fundamental concepts of chemistry and physics. There is a reorientation, in the development and understanding of the concepts toward demonstrations and direct pupil experiences and away from reliance on descriptive presentation.

FOCUS ON THE SCIENCES. Units of fundamental science content in chemistry, biology, physics, and earth science are presented separately. While maintaining the internal structure of the separate sciences, each unit is developed by building upon previous concepts, thus expanding the pupil's problem-solving ability.

INTEGRATION OF LABORATORY WORK. Student laboratory experimentation is considered, universally, as an integral part of science courses. It is a known fact that direct involvement makes the greatest impact. In this *Science: Grade 9,* a laboratory period is planned in each block of five lessons. (Previously, double and then, daily lab periods were assigned.) A careful analysis of feedback, interviews, and conferences has revealed that this new allotment is generally more satisfactory and realistic.

STRESS ON CRITICAL THINKING. Science as a method of thinking, of investigation, and of operation is emphasized. Development of carefully selected concepts contribute to the deeper understanding of the nature, structure, and interrelationships of the sciences. The selective process requires sufficient time for mature reflection. This imposes a definite limitation on the total content of the science course.

FOCUS ON HUMAN RELATIONS. Science offers many opportunities for fostering understanding among the various groups and could, therefore, make a positive contribution toward the achievement of better human relations.

Science, with its stress on the methods and attitudes of scientists, provides a useful tool in eliminating some of the myths, stereotypes, and prejudices on which many misconceptions are based. Racism, and its concomitant, discrimination, are unsupported by scientific data and are based on a deep misunderstanding of culture as well as the biology of the human species.

Whenever possible, activities and suggestions have been included which shed light on the similarities and differences among the various races and ethnic groups and which build on the positive contributions of all groups. The different cultures and geographical areas have contributed to the American way of life and is a heritage which we hold in high regard. Identity with this American heritage broadens perspectives and insights and enhances the self-image and self-identity of all students, the minority as well as the more privileged youngster.

FORMAT

In accord with the objectives and innovations, a specific format was planned. Among its special features are:

- Topical outline
- Sequential units in each of four science areas

- Division of each unit into sections for ease in reviewing and testing
- Outcomes listed for each lesson of every unit
- Each section designed to be a complete lesson
- Direct reference to interrelationships among the sciences as they occur in the development of the lessons
- Logically developed classroom lessons with specific content, methodology and techniques
- Designated laboratory lessons including explanatory notes for the teacher and worksheets for the pupils
- Enrichment materials, such as assignments, questions, reports, and projects
- Designated lessons, identified as "Review and Reinforcement" lessons, offer the teacher frequent opportunities for experimentation, enrichment, testing and review.

This new science teacher's guide for grade 9 contains a series of basic lessons that are required for all students. In addition, each of the lessons suggests and describes enriching activities for those students who possess both the interest and ability to take advantage of them. Every attempt is made to assure a high degree of understanding of the basic content and processes of science.

By means of this pioneering organization of the junior high school science program, the inner-city child will, for the first time, be better equipped to enter the academic mainstream in science in our high schools.

The format also provides the framework within which are envisioned the two basic types of science lessons, the classroom recitation and the laboratory lesson requiring direct student involvement in the processes of science. Both are described in the sections that follow.

THE CLASS LESSON

Of the approximately thirty lessons comprising each of the four units in the ninth grade, 18-19 may be classified broadly as classroom recitation lessons. Approximately 5-6 lessons are identified as laboratory lessons. The remaining 5-6 lessons are identified as "Review and Reinforcement" lessons. As suggested in the introduction of these lessons, the teacher may select the suggestions most appropriate for him. Included in the many suggestions are:

- Audio-visual materials (films, filmstrips, transparencies, single-concept film loops, etc.)
- Test questions (short answer, fill-in, matching)
- Reading Comprehension
- Research projects
- Reports
- Models
- Trip visits

A careful analysis of the feedback schools indicated overwhelmingly that present science courses are overcrowded with content. To overcome this situation, the revision committee was directed to reduce the existing content, and to develop those fundamental concepts and processes of science which will secure maximum interest and understanding on the part of the students.

Each one has been numbered sequentially and tailored to fit the standard forty-minute period. Following generally accepted planning procedure, the lessons include a statement of the aim in question form, motivation, development, and a terminal summary. Among the specific techniques that may be found within the broad classification of classroom lessons are demonstrations, discussions, lectures, reports, seminars, reviews, and individual laboratory work of short duration.

In order to help the inexperienced teacher and the one whose area of specialization does not coincide with that of the unit, each lesson has been worked out in detail. The detail encompasses not only methodology, techniques, content, and outcomes but also inductive development where possible and connection with lessons that precede and those that follow. Because so much of the burden of lesson planning is obviated by this approach, more time will be available for the preparation of the many demonstrations and other multisensory experiences called for in almost every section of each unit.

The class lessons foster an enquiring attitude on the part of the pupils in that they feature thought-provoking questions and demonstrations. As the teacher calls for and encourages pupil replies and questions, a stimulating scientific air will prevail in the classroom. Experience shows that short question periods at the start and at the conclusion of lessons are highly effective in orienting the attitude and thinking of students in the scientific approach to the solution of science problems.

Since reporting is an important pupil activity in the units, the teacher should acquaint the pupils with reliable sources of information and with the proper form, content, and structure of a report. Stress should also be placed upon effective presentation of reports to the class. Reports should not be read. The class should evaluate the reports on the basis of such criteria as clarity, interest, completeness, and use of illustrative material. A chart of the selected criteria, prominently displayed, is invaluable as an aid to achieve stimulating reports.

Finally, the lessons in this publication are not intended as a substitute for individual planning. Lesson plans must be adapted and geared to meet the specific needs of the students in a given class.

THE LABORATORY LESSON

Individual laboratory lessons are effective means of inculcating scientific attitudes, procedures, and modes of thinking. Consequently, pupils should be given the opportunity of planning the laboratory exercises instead of being directed step by step. After planning, pupils should be permitted initiative to perform the experiments. This the present course of study aims to do.

However, for successful planning, the teacher must provide the required background techniques and information prior to the laboratory experiences. In addition, adequate safety instruction is more than ever important in laboratory work which allows much freedom to the pupils. Each teacher must secure a copy and acquaint himself as well as the pupils with the contents of Board of Education publication, "For Greater Safety in Science Teaching," 1964.

Approximately one period per week is devoted to laboratory investigations by the students. The laboratory lessons contain explanatory notes to the teacher and worksheets for the student. Initially, the worksheets contain detailed step-by-step procedures, which later give way to less detailed problem-solving instructions. It may readily be observed that the laboratory lessons are not all of the problem-solving variety; some offer the opportunity to acquire techniques or skills, while others are designed to teach concepts in a step-by-step manner.

The laboratory lesson is divided into three phases: the introductory or preparatory phase, the work or laboratory phase, and the discussion phase. During the introductory interval, it is suggested that materials be distributed quietly, on trays, by the laboratory specialist and that the pupils be given the required information. While this is going on, the teacher should seek to have the slower classes delineate the problem and to suggest possible methods for its solution. For the laboratory period, the class should be divided into groups of 2-4 pupils depending upon the availability of equipment and materials. It is suggested that the pupils retain their original groups and select a group leader who will be responsible for security and returning the equipment. The pupils should be instructed to work together, to discuss and rotate tasks, and to call upon the teacher for help as required. Normal classroom decorum should be maintained during the laboratory interval in order that pupils may hear instructions from the teacher.

It is also suggested that the teacher and laboratory specialist circulate about the room to detect difficulties and to encourage and assist individual pupils. Some time should be provided at the end of the period for discussion of procedures, observations and conclusions and for answering questions. A good laboratory session points up many new problems that may lead to fruitful investigations .

It cannot be overemphasized that if the class is properly trained in laboratory decorum and responsibility, the laboratory work should proceed without difficulty and with much profit. To achieve this end, the teacher must provide proper training in acceptable laboratory procedures.

Every pupil should be required to keep a science notebook with a laboratory section in which to record his data, observations, conclusions, and answers to the summary questions for each laboratory lesson. If he is encouraged to see new problems as he analyzes the data, he will suggest hypotheses for their solution which may become the bases for additional experimentation, projects, and laboratory work.

HOW TO USE THIS BULLETIN

The order of presentation, the motivation, and the activities may be altered on the basis of the teacher's experience, nature of the class, and creative bent of the teacher. However, the basic minimal outcomes should remain intact. Enrichment activities, in harmony with the aim and the outcomes of the lesson are included to meet specific needs. The New York State Handbooks in General Science, Chemistry, Physics, Biology and the Earth Sciences are excellent sources of pertinent activities.

The teacher who is a beginner in one or more of the sciences is advised to follow the lessons closely. To insure a measure of success, the demonstrations and laboratory exercises must be tried out in advance. All teachers are advised to schedule frequent reviews, to administer short quizzes and longer examinations, and to grade notebooks regularly. Some teachers advocate the distribution, collection, and grading of sets of study questions.

One word of caution: The syllabus has been so designed that the laboratory lessons may be presented at the time specified or within a reasonable time thereafter; they should not be attempted before the student has learned the necessary techniques and preparatory content.

ORIENTATION

Experience has shown that the pupil should undergo a period of introduction and orientation before embarking upon any course of study. The teacher will be in the best position to judge the time and the nature of the preliminary material to be introduced. However, the following suggestions may prove helpful in the task of orienting the pupil to the study of science and to assuming his responsibilities.

- Open the course with planned motivation. Some teachers prefer discussions of summer science experiences or expectations from the study of science. Others capitalize on interesting science current events.
- Discuss the types of lessons to be met in science, particularly the laboratory exercise.
- Practice forming laboratory groups and preparing for laboratory work.
- Acquaint the pupils with the course requirements; for example, notebooks, contributions to class discussion, reporting, assignments, regular study, quizzes, and examinations.
- Illustrate, define, and examine the scope of the four sciences to be studied.
- Develop a daily awareness of the degree of understanding of content and processes of science on the part of students and measures to be taken to meet specific problems that may arise.

Unit I
PHYSICS

Sound
Light

IMPORTANT NOTE TO THE TEACHER

The sections of the text which are printed in italics (the type used in this note) are intended as enrichment material.

SOUND

Suggested Lessons and Procedures

1. WHAT IS SOUND?

Outcomes

- Sound is produced by vibrating bodies.

Motivation

The concepts to be developed in this unit are an extension of ideas initially presented in grades three and four. The teacher may wish to refer to these elementary science bulletins and aid pupils in recalling these earlier learning experiences.

Have pupils observe the following demonstrations:

1. *vibration* of ruler or hacksaw blade clamped to the desk
2. suspension of a ping-pong ball or pith ball against a *vibrating* tuning fork
3. partial immersion of a *vibrating* tuning fork in a large battery jar of water.

Development

1. While three pupils draw and label diagrams of the demonstrations at the chalkboard, encourage the rest of the class to record their own observations in notebooks.

2. Challenge the students to identify the similarities and differences in the demonstrations. (Sounds are produced in each case although different materials are used.)
3. Ask pupils to generalize from these demonstrations as to how sounds are produced. (Sounds are produced by vibrating bodies.)
4. Have each pupil test the generalization by holding his fingers gently around his throat while silent and then while he hums or talks.
5. Ask pupils to describe what they feel when fingers are held around the throat. (Vibration.)
6. Ask pupils what it is that vibrates in various stringed or reed instruments. (Have some actual instruments demonstrated.)
7. *Play a portion of a phonograph record and have the class trace the production of the sound from the record grooves to the needle through the amplifier to the speaker. (Emphasize the mechanical rather than the electronic aspect of this phenomenon.)*

Summary

1. How are all sounds produced?
2. Inflate a balloon. Allow the air to escape slowly by constricting the neck. Challenge the class to identify the source of the sound being produced.

Homework

1. Fill in the table:

SOUND	VIBRATING OBJECT
Tearing paper	
Whistling	
Clapping hands	
Ringing telephone	
Radio	

Materials

Ruler
C-clamp
String
Pith ball
Battery jar
Balloon
Hacksaw blade
Ping-pong ball
Ring stand and clamp
Tuning fork
Phonograph and record

2. HOW DO SOUNDS DIFFER?

Outcomes

- The loudness of a sound depends on the energy used to make that sound.
- *The larger the amplitude, the louder the sound.*

Motivation

A pupil, standing in front of the classroom, should be instructed to clap his hands so that the sound is inaudible.

In successive stages he should clap more energetically and the pupils should be instructed to raise their hands as they hear the clapping. Ask, "Why does the sound become louder as we clap our hands harder?"

Development

1. List all suggested answers on the chalkboard. Challenge the class to suggest ways of testing their hypotheses, using the displayed materials.
2. Display a tuning fork, meterstick and clamp, and ping-pong ball suspended by string on a ring stand.

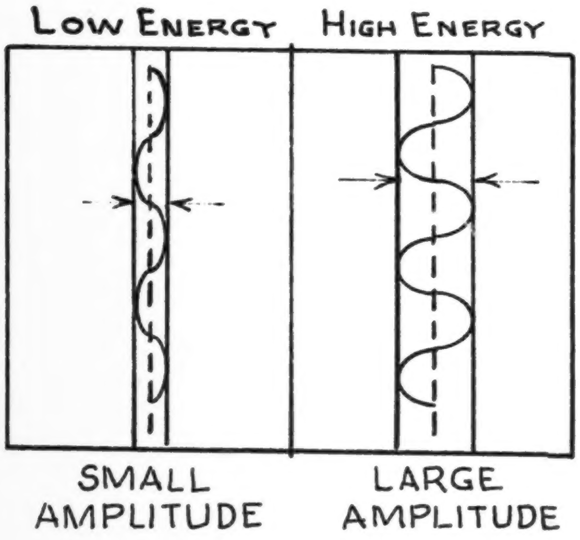
   NOTE: A good method for suspending the balls is to thread a long sewing needle and pass this through the ball. Remove the needle and knot the thread.
3. Experiments such as the following may yield desired outcomes:
   a. tuning fork struck gently vs. tuning fork struck more energetically.

b. meterstick vibrated gently vs. meterstick vibrated more energetically.

NOTE: Students should be instructed in the proper use of the tuning forks since they are easily damaged when struck on hard surfaces.

4. Recalling from grade 8 learnings that sound is a form of energy, develop with the class the concept that the loudness of a sound depends on the amount of energy released.

5. *Gently strike a low-frequency tuning fork and draw a pointed edge across a smoked glass plate. Repeat this procedure, using the same tuning fork struck more energetically. Have the class observe and compare the two traces. Define the width of the trace produced as the amplitude.*



Summary

1. How do our ears detect an increase in the energy of a sound?
2. Explain why a church bell is louder than a telephone bell.
3. *Draw two wave tracings on the chalkboard and have the class identify the relative loudness.*

Homework

1. Why can a loud sound break your eardrum?

2. How does a megaphone increase the loudness of a person's voice?
3. *Using a ping-pong ball and a radio speaker, how can we show that the vibrational energy of the speaker increases as the radio is made louder?*

Materials

Tuning fork
Clamp
Meterstick
Ping-pong ball on stand
Smoked glass plate

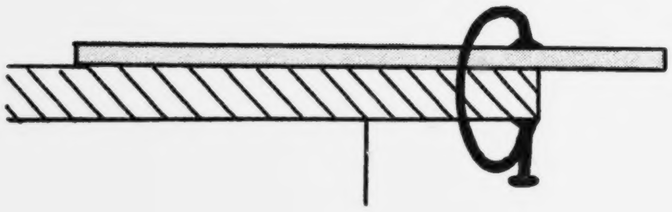
3. HOW CAN DIFFERENT SOUNDS BE PRODUCED?

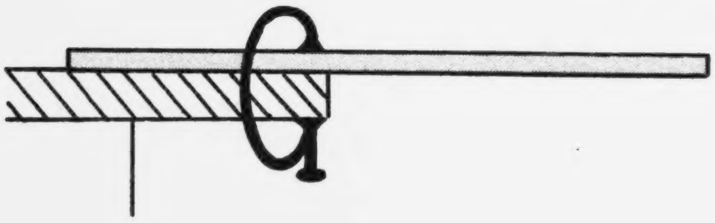
Outcomes

- A vibration is a repeated back and forth movement.
- One complete back and forth movement is called one vibration.
- The number of vibrations per second (hertz) is related to the pitch. (The recently adopted term for vibrations per second is *hertz.)*

Motivation

Set up the following demonstration:



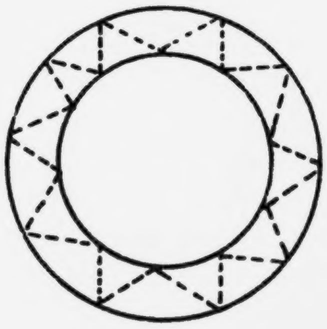


Depress each of the metersticks and allow them to vibrate freely. Instruct the students to record all observations (compare sound and rate of vibration). Repeat several times.

Development

1. Ask the class to report what they heard and saw.
2. Demonstrate Savart's Toothed Wheel (14-5528). (Speed of rotation should remain constant for entire demonstration.) Have students observe what they heard and saw.

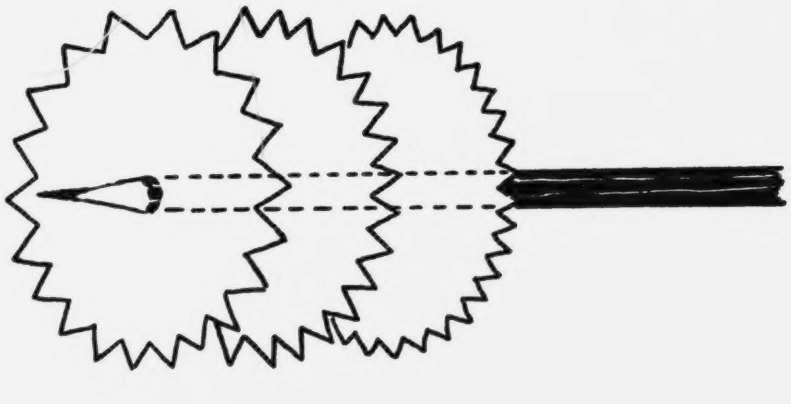
   Note: If Savart's Wheel is not available, one may be constructed as follows:



Using rigid cardboard (oaktag), cut out three discs each having a 3″ diameter.

Draw a series of teeth on the first disc as shown. Cut along dotted line. Repeat this with discs 2 and 3. (Increase number of teeth on each wheel by at least 4.)

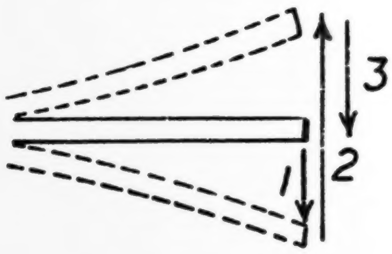
To assemble: Space each disc about 1 inch apart. Tape to pencil.



3. Challenge the class to describe, in words, how the sounds differed. Identify this difference as a difference in *pitch.*
4. Ask, "*Why* did the sounds differ?" Establish that a large number of vibrations per second produced a high pitch, while a small number produced a lower pitch.

NOTE: *Discourage* description of pitch in terms of *loud* and *soft.* Descriptions should be restricted to *high* and *low.*

5. From their observations, have the students define vibration. Develop the concept of one complete vibration. The following diagram may be useful:



One vibration is defined as one complete cycle of movement.

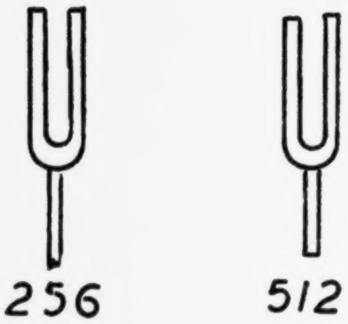
6. After the relationship between pitch and the number of vibrations per second has been established, develop with the class the need for counting the number of vibrations per second. One vibration (cycle) per second is known as one *hertz.*
7. Define frequency as the number of hertz.
8. *Display eight identical test tubes in a rack. Fill test tubes with water in such a way that a scale is produced when each is struck. Challenge class to account for the production of the musical scale.*

Summary

1. Display two differently pitched tuning forks. Have the class sketch and label each of these in their notebooks. After striking the tuning forks, have the class answer the following questions:
    a. Which tuning fork has the higher pitch?
    b. How do you know which tuning fork is vibrating more quickly?
2. Have the class draw a diagram showing how the tuning fork vibrates.

Homework

1. Using a labelled diagram, describe an experiment which shows that the number of vibrations per second is related to pitch.



2. Which tuning fork will produce the higher pitch? Why?

Materials

2 metersticks	Savart's wheel
2 C-clamps	2 tuning forks
	8 test tubes and rack

4. HOW DO MATERIALS DIFFER IN THEIR ABILITY TO TRANSMIT SOUND?

LABORATORY LESSON

Outcomes

- Dense, rigid materials transmit sounds best.
- Soft materials absorb sound.

Development

1. Distribute Laboratory Worksheets and read with class.
2. Distribute materials.
3. Challenge the class to design experiments which will determine the relative abilities of the various materials to transmit sound.
4. Encourage pupil evaluation of the techniques proposed.
5. Have the class perform the experiments after these have been discussed and modified.

Summary

Refer to questions on Worksheet to reinforce concepts.

(May be duplicated for use by pupils)

LABORATORY WORKSHEET—PHYSICS: LESSON 4

Problem: How do materials differ in their ability to transmit sound?

Materials

Tuning fork
Rubber stopper
Wooden dowel
Plastic ruler
Sponge
Board eraser
Glass rod
Metal rod (tripod leg)

Procedures and Observations

1. Develop, with your teacher, a method for testing the ability of materials to transmit sound.
2. Perform your experiments and record your observations on the table.

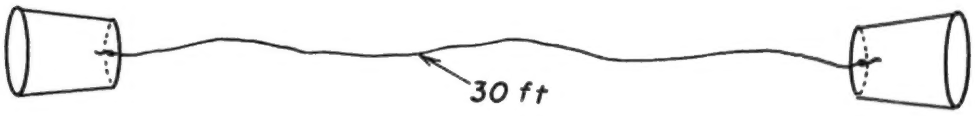
Material	Ability to Transmit Sound

Summary

1. Of the materials tested in your experiment, which would be best for soundproofing a room? Why?
2. In the *Wild West* the outlaws put their ears to the railroad tracks. Why did they do this?
3. How do your parents let the janitor know you are not getting enough steam? Why do your parents bang on the pipe?
4. Why does iron transmit sound better than sponge rubber?

Homework

1. Write up the experiment describing what you did and explaining what you found out.
2. Make a string telephone by doing the following:
    a. Punch a hole in the bottom of 2 tin cans or paper cups.
    b. Using about 30 feet of string, thread the ends through the holes and knot them.



NOTE: String should be stretched tight and not touch anything.

3. Whisper to your friend.

   Whisper into the cup while your friend places his cup to his ear.

Questions

1. Why did your friend hear you when you whispered into the cup?
2. Try this while holding the string. Is there a difference? Explain?

◆

REVIEW AND REINFORCEMENT (1-4)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Reading Selection

The following passage may be duplicated for pupils.

> If you were to put your head under water as someone claps two rocks under water several yards away, you will be surprised at how loud the sound is. Water is a good conductor of sound waves.

The Navy used this information during the last war to detect enemy submarines. Any sound made by propellers or by a hammer dropped inside the submarine could be heard several hundred yards away with the use of sensitive listening devices.

Sound waves under water are also used to measure the depth of water beneath a ship. From the bottom of the ship a sound wave is sent downward. It is well known that sound travels 4800 feet (almost a mile) a second through water. At this speed the sound wave travels downward, hits the sea floor, and is reflected back up. The time it takes the echo to return to the ship is carefully measured. The longer the time takes, the deeper the water. The depth of water under a ship can be read directly on a gauge in the pilot house.

Many fish also make sounds in water, and these sounds can be heard with suitable listening devices. Fishing fleets often locate schools of fish by "listening" for them.

Answer the following questions:

1. The best title for this section is
   a. Fishing Boats
   b. Echoes
   c. Underwater Sound
   d. Submarine Detection
2. The speed of sound in water is about (a) 4800 feet/hour (b) 1 mile/minute (c) 1 mile/second (d) 4800 feet/second.
3. During the second World War, the Navy could detect submarines underwater because (a) submarines are made of metal (b) water is a good conductor of sound (c) submarines travel slowly (d) submarines carry torpedoes.
4. Reflected sound waves can also be called (a) images (b) echoes (c) gauge (d) all of these.
5. Forty-eight hundred feet is almost (a) 1 city block (b) distance to ocean bottom (c) greatest distance sound can travel (d) 1 mile.
6. Fish can be detected under water because (a) fish make sounds (b) they are an important source of food (c) they are often found in deep water (d) fish absorb sound waves.
7. If a sound wave is sent downward from a ship and is received 4 seconds later, the depth of the water is most likely (a) 4800 ft. (b) 9600 ft. (c) 15,200 ft. (d) 18,800 ft.

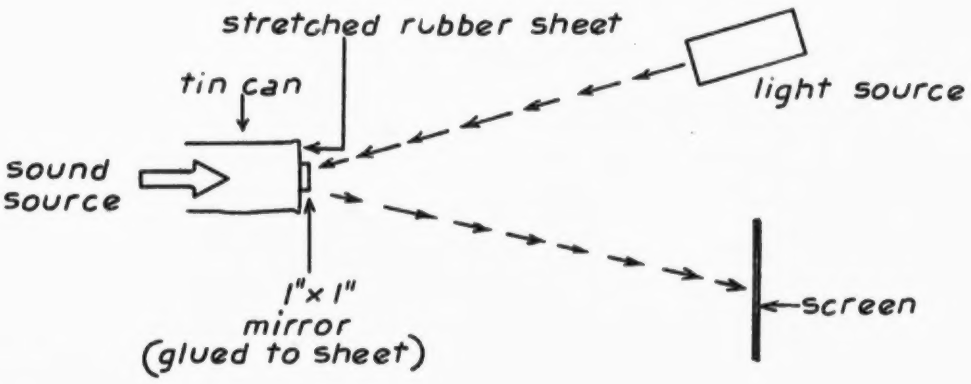
8. A gauge is a type of (a) meter (b) ship (c) sound wave (d) fish.
9. To detect means to (a) reflect (b) absorb (c) destroy (d) find.
10. To avoid underwater detection, a submarine should (a) speed up its engines (b) make a lot of noise to fool the enemy (c) shut all engines (d) come to the surface.

Topics for Reports

1. Alexander Graham Bell and the Phonograph
2. Sonar
3. How Bats Navigate

Discussion — Demonstration

A mechanical model to demonstrate sound waves may be constructed as follows:


stretched rubber sheet
tin can
light source
sound source
1"x 1" mirror (glued to sheet)
screen

Possible Observations

1. The louder the sound, the greater the amplitude of vibration.
2. Sounds produce characteristic patterns.

◆

5. HOW CAN THE PITCH OF A STRINGED INSTRUMENT BE CHANGED?

Outcomes

- The pitch of a vibrating string depends upon:
  - length of string
  - tension on the string
  - width of the string

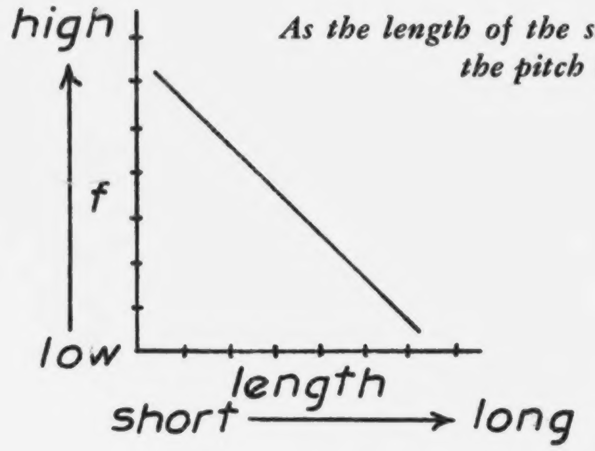
Motivation

Display a stringed instrument such as a guitar or violin. Challenge the class by asking, "What would orchestras be like if all instruments were able to produce only one note?"

Development

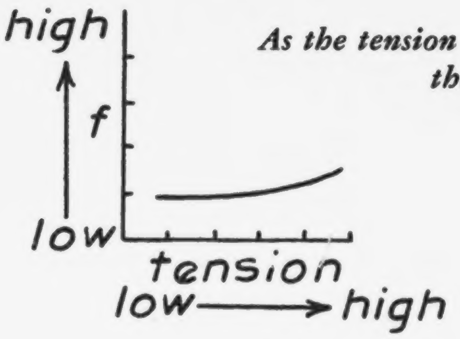
1. Allow the class to examine the instrument while you identify its parts: tuning peg, frets, resonating box.
2. Have the class list factors which might affect the pitch of the instrument.
3. For each factor have them make a hypothesis about the way it might affect the pitch; have them justify each hypothesis based on the fact that the pitch of a sound depends upon the frequency of vibration of the source.
4. Have the class suggest various methods to test their hypotheses.
5. Encourage pupil volunteers to come to the front of the room to perform each of the suggested procedures while another pupil records the observations on the chalkboard.
6. Establish the following generalizations:
   a. The greater the length, the lower the pitch.
   b. The greater the tension, the higher the pitch.
   c. The greater the width, the lower the pitch.

   NOTE: Item *6c* pertains only to strings made of the same material.
7. *a. If the tension and mass of a string remain constant, the relationship between frequency and length may be shown graphically:*



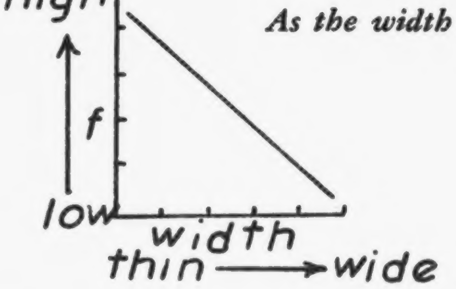
As the length of the string increases, the pitch becomes lower.

b. If the length and mass of a string remain constant, the relationship between frequency and tension may be shown graphically:



As the tension on the string increases, the pitch becomes higher.

c. If the length and the tension of a string remain constant, the relationship between frequency and width may be shown graphically:



As the width of the string increases, the pitch decreases.

Summary

1. What factors are important in changing the pitch of a stringed instrument?
2. How does varying each factor change the pitch?

Homework

1. How does a guitar player make use of the fact that tension affects the pitch of a vibrating string?
2. How does a violin player make use of the fact that changes in length affect the pitch of a vibrating string?
3. The strings on the right hand side of a bass fiddle are thicker than those on the left. Explain why this is so.

6. HOW CAN THE SPEED OF SOUND BE MEASURED?

Outcomes

- The speed of sound is related to the density of the medium through which it is transmitted.
- The speed of sound in air is approximately 1100 feet per second.

Motivation

It is known that lightning and thunder occur simultaneously. However, very often the flash of lightning will be seen several seconds before the thunder is heard. Can you explain the reason for this?

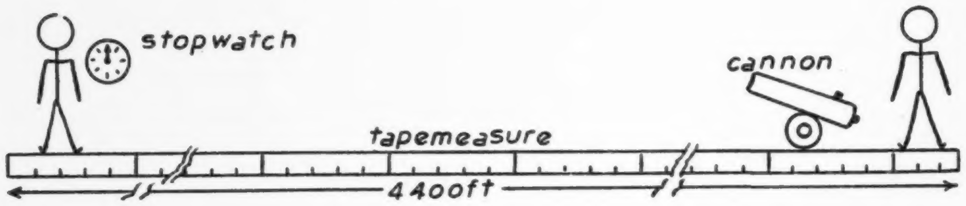
Development

1. Elicit from the class that since the lightning is seen before the thunder is heard, it would appear that light travels at a greater speed than sound. (Approximately one million to one.)
2. Challenge the class to cite instances which illustrate a time lapse between an event and its sound. Pupils may suggest the following: in the bleachers, the batter is seen to hit the ball before the sound

is heard; in the balcony of a large concert hall, the bass drum is heard a short time *after* it is struck.

3. Given a tapemeasure, cannon, and stopwatch, challenge the class to suggest experiments to measure the speed of sound.

4. List and illustrate the suggested methods on the chalkboard. The following diagram may be helpful:



5. The teacher might suggest that if this experiment were actually performed, the following data would be obtained:

DISTANCE	TIME
5280 ft.	4.8 sec.
10560 ft.	9.6 sec.
21120 ft.	19.2 sec.

6. Place the formula $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$ on the chalkboard and have the class calculate the speed of sound for the data on the chart.

7. Explain to the class that methods similar to those already discussed have been used to determine the speed of sound in other materials.

MATERIAL	SPEED OF SOUND
Air	1100 ft./sec.
Water	4800 ft./sec.
Steel	16,000 ft./sec.

8. Define the term *medium* (pl.—*media*) as any substance through which sound can travel.

9. Establish the generalization that the speed of sound is related to the density of the medium through which it is transmitted; the denser the medium, the greater the speed.
10. *Ask, "Does pitch or loudness affect the speed of sound?"*

Summary

1. A flash of lightning is seen and the thunder is heard 5 seconds later. How far away is the storm?

Homework

1. You're sitting in the bleachers and the batter hits the ball. If you hear the sound ⅓ second later, how far is home plate from you?
2. Porpoises communicate underwater. Birds communicate by sound through air. Which animal has the faster means of communication? Explain.

7. HOW DOES SOUND TRAVEL FROM ONE PLACE TO ANOTHER?

Outcomes

- Sound waves require a medium.
- Sounds travel as longitudinal waves.

Motivation

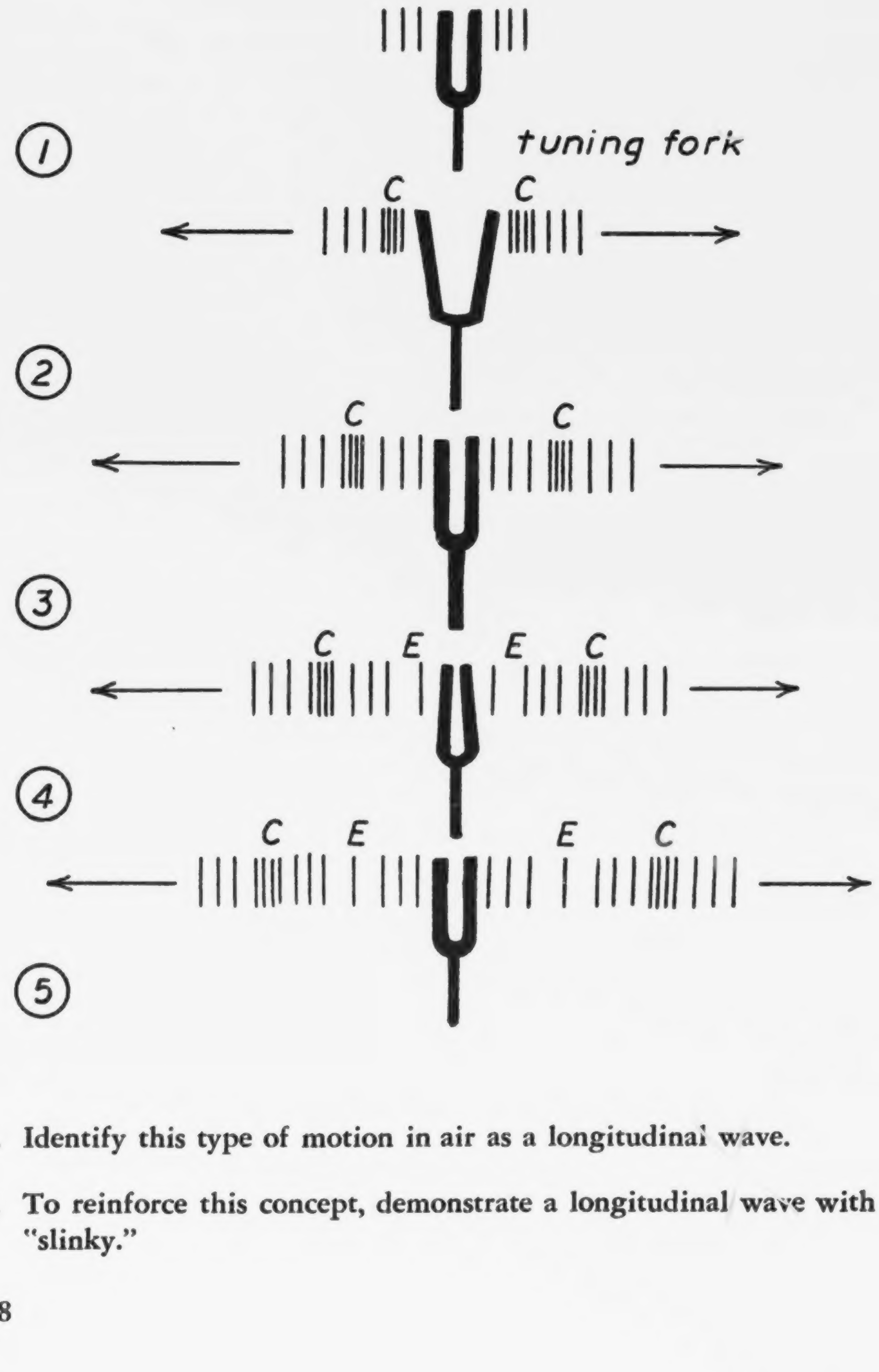
Set up the bell in vacuo demonstration. While the bell sounds, slowly evacuate the jar.

Development

1. Place a labelled diagram of the apparatus on the chalkboard and have the class draw the diagram in their notebooks.
2. Have several students report their observations and suggest theories to account for them.
3. Establish with the class the fact that the vacuum pump is removing the air (medium) from the battery jar.

4. Elicit from the class that sound requires a medium in which to travel.

5. Ask, "How does sound travel through a medium?" Suggest that an answer might be found, using the knowledge of how a tuning fork vibrates. The following diagram is needed:



6. Identify this type of motion in air as a longitudinal wave.

7. To reinforce this concept, demonstrate a longitudinal wave with a "slinky."

8. It will be necessary to indicate that it is the energy that is moving, while the air particles simply move back and forth.

9. By referring to the diagram, develop the understanding that compressions are caused by the outward push of the prongs, while the expansions are caused by the inward motions of the prongs. This combination of motions taken collectively is called a longitudinal wave.

Summary

1. Why is the moon referred to as a silent world if it has no atmosphere?

2. Explain why sounds can travel across a room even though the air molecules do not travel across the room.

Homework

1. Explain why sound does not travel through a vacuum.

2. Describe an experiment to show that sound can travel through air but not through a vacuum.

Materials

Bell in vacuo
Vacuum pump

Tuning fork
Slinky

8. HOW DO SOUNDS BEHAVE IN A COLUMN OF AIR?

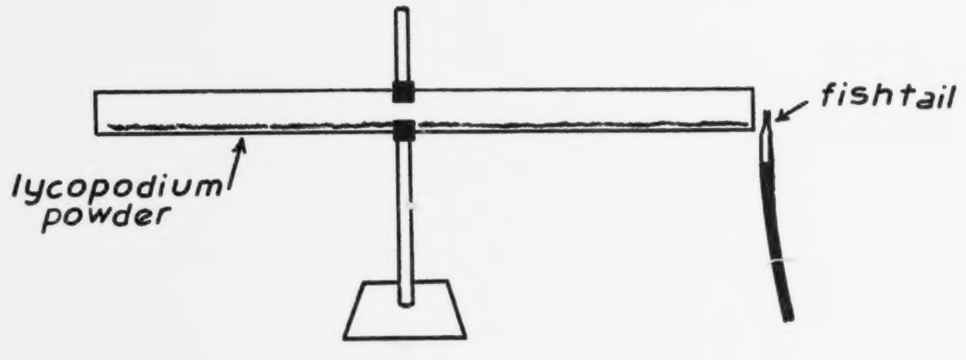
LABORATORY LESSON

Outcomes

- Sound waves may interfere with one another.
- In constructive interference, sound waves combine to produce a louder sound.

Development

1. Set up the following demonstration:



2. Sift some lycopodium powder or fine cork dust into a horizontally placed glass tube whose length is at least three feet and whose diameter is about one and one-half inches.
3. Using a fishtail burner top and a rubber tube, blow air *across* the end of the glass tube.

   NOTE: Do not blow into the tube.
4. Have the class observe the vibrating particles and the pattern of alignment.
5. Identify the areas of concentration as *compressions* and the less dense areas as *expansions.* (Recall from previous lesson.)
6. Distribute materials and pupil Worksheets.

Summary

Refer to questions on pupil Worksheet.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 8

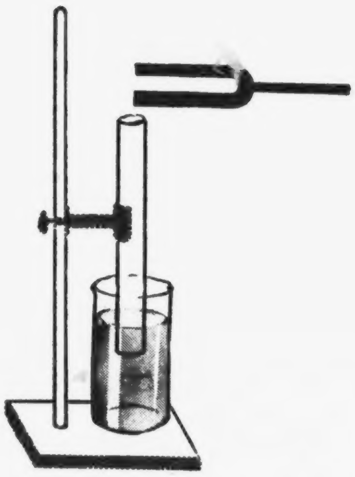
Problem: How do sounds behave in a column of air?

Materials

Large beaker
Ring stand and clamp
Hollow tube, approx. 14"
(cut from 1" glass or metal tubing Item 13-2838S-1)
Tuning fork
Large rubber stopper
Rubber band

NOTE: Never strike a tuning fork against anything but the rubber stopper.

Procedures and Observations



1. Fill the beaker with water.

   NOTE: The water serves as a simple way of changing the length of the air column in the tube.

2. Set up the apparatus as shown:
3. Strike the tuning fork and hold it above the open end of the glass tube. Note the *loudness* of the sound.
4. Repeat this procedure several times, each time changing the length of the column of air. (Raise and lower the tube.)

   NOTE: The sound waves travel down the tube, strike the water, and are reflected back again.

Summary

1. What effect on loudness did changing the length of the tube have?
2. When an incoming compression passes an outgoing compression or an incoming expansion passes an outgoing expansion, the sound produced will be loud. This is called constructive interference. Explain why the loudness changed as the length of the air column changed.
3. In the demonstration performed by your teacher, what did the bunching up (concentration) of powder represent?

Homework

1. How does the length of a tube affect the sound coming from it?
2. Why is it important that organ pipes have definite lengths?

◆

REVIEW AND REINFORCEMENT (5-8)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Topics for Reports

1. Breaking the Sound Barrier — Ernst Mach
2. The Seismograph
3. The Human Ear
4. Ultrasonics

Films and Filmstrips*

Sound Waves. 16 min. U.W., 1951.

Gives examples of different kinds of sounds and shows how sounds are produced. Demonstrates amplitude, frequency and wavelength and pictures transverse and longitudinal waves. Explains the properties of sound waves and shows some of the uses of sounds.

Simple Waves. 30 min. Modern

Pulse propagation on ropes and slinkies shows elementary characteristics of wave such as speed in different media. Torsion-bar wave machine used to repeat experiments demonstrating reflection and other phenomena.

Sound Waves and Their Sources. 11 min. Encyclopaedia Britannica Films, 1950.

Identifies the three major sources of sound: vibrating columns of air, vibrating surfaces, and vibrating strings. Laboratory demonstrations and animation explain the meaning of loudness, pitch, and quality.

Discussion — Demonstration

1. The teacher, by arrangement with the music department, should have a member of the string, woodwind, brass, and percussion sections of the school orchestra invited to the classroom to demonstrate their musical instruments.

---

* See *Instructional Films and Tapes* (Curriculum Bulletin No. 17, 1967-68 Series), Board of Education of the City of New York.

2. Have each of the pupils demonstrate his musical instrument.
3. Elicit from the class:
   a. Vibrations of reeds, strings, and lips produce sounds.
   b. These vibrations are caused by applying energy.
   c. The more energy applied, the louder the sound.
   d. The tighter the string, lips, etc., the higher the pitch.
   e. The shorter the strings, air column, etc., the higher the pitch.
   f. The thinner the strings, the higher the pitch.

◆

9. HOW DO SIZE, SHAPE, AND MATERIAL AFFECT THE SOUND MADE BY AN OBJECT?

Outcomes

- Sounds may differ in quality.
- The quality of a sound depends upon the size, shape, and material of the object.

Motivation

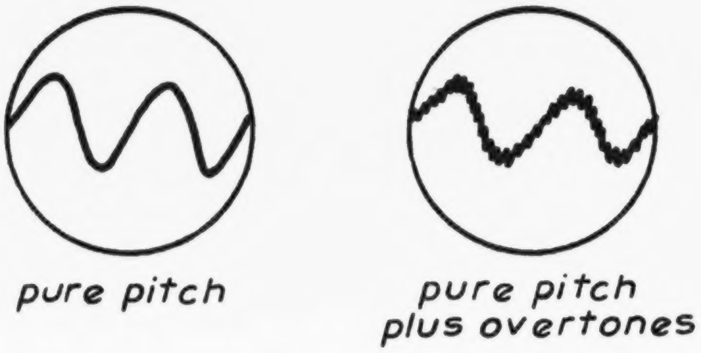
Ask, "If a girl and boy sing the same note with the same volume, will they sound the same?"

Development

1. Allow class discussion of the motivation question without supplying a definitive answer. Have several pupils attempt to do this.
2. Strike a tuning fork and touch the handle to several objects in the room such as chalkboard, desk top, paper, etc. Elicit from the class that although the tuning fork produces the same pitch in each instance, different sounds are produced as other materials are forced to vibrate along with it.
3. Challenge the class with the following: "Can you account for the

difference in the sounds produced?" This discussion should result in the conclusion that additional frequencies are being produced by the object in contact with the tuning fork.

4. Identify these additional frequencies as overtones.
5. Develop the following: Overtones are responsible for the *quality* of a sound.
6. Illustrate the difference with the following diagram:



Note: If available, repeat the demonstration showing the wave forms on an oscilloscope. Call attention to the simple wave (pure sine wave) produced by the tuning fork and the complex wave produced when overtones are added.

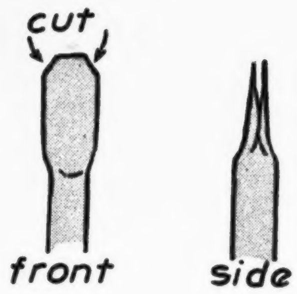
7. By comparing and contrasting such instruments as the clarinet and trumpet, establish that the size, shape, and material are responsible for the different sounds produced.
8. *Strike tuning forks of the following frequencies: 128, 256, 512. Have the class identify the relationship between the sounds (one octave apart).*
9. *Define the lowest tone of this series as the* fundamental, *the following tones as* harmonics. *Show the numerical relationship between the frequencies as a doubling.*

Summary

1. Have the class account for the difference between masculine and feminine voices.
2. When the same note is played on the piano and the violin, why do they sound different?

Homework

1. Obtain two soda straws of different materials but alike in all other respects (plastic or paper).
    a. Flatten about ½ inch of the ends of the soda straws.
    b. Cut off the corners as shown.
    c. Place the flattened end in your mouth and blow until a sound is produced.
2. How and why are the sounds different?



Materials

Oscilloscope	Tuning forks (128, 256, 512)

10. HOW DO SOUNDS COMBINE?

Outcomes

- Sound waves may combine with each other to produce audible beats.
- If a vibrating tuning fork is held near another tuning fork of the same frequency, the second one will begin to vibrate. This is called resonance.

Motivation

Strike two tuning forks of the same frequency. Allow the class to hear the sounds produced. Alter the frequency of one by placing a small clamp or a rubber band around one of the prongs. Strike each of the tuning forks at the same time and be sure to allow *all* pupils to hear the new tones produced.

Development

1. Ask the pupils to describe the sounds they heard.
2. Identify the *beats* as the warbled loud-soft effect produced when a clamp is fastened to one of the prongs.

3. Challenge the class to account for the difference in sounds after placing the clamp or rubber band on the tuning fork. Establish that by adding material to the tuning fork, its frequency is slightly altered. (The greater the mass, the greater the change in frequency.)

4. Explain to the class that when two tuning forks with *slightly* different frequencies are struck simultaneously, audible beats are produced. The number of beats produced per second is equal to the difference in the frequency between the two tuning forks:

TUNING FORK I	TUNING FORK II	BEATS/SECOND
256	258	2
512	519	7

5. Ask the class to suggest ways in which audible beats may be used to facilitate the tuning of most musical instruments.

6. Demonstrate the resonance boxes. (The opened ends should be facing each other.) Repeat the demonstration several times and have the class make observations.

7. Identify the phenomenon as resonant vibration. (When objects are forced to vibrate, characteristic sounds are produced. This sound is referred to as the object's natural frequency of vibration.) If two objects having the same natural frequency of vibration are placed close to each other, and one is forced to vibrate, the other will begin to vibrate with it.

8. *Review with the class the parts of the human ear. Emphasize the function of the eardrum. Have the class suggest the relationship between resonance and the vibrations of the eardrum.*

Summary

1. Two violins simultaneously sound the note *A*. If beats are heard, are they in tune? Explain.

2. An opera singer can shatter a glass with her voice. Explain this, referring to what you have learned.

Homework

1. Explain why the hollow box of a violin amplifies the sound of the strings.

2. Fill in the table:

TUNING FORK I	TUNING FORK II	BEATS/SECOND
512		4
	262	6
1024	1026	

3. *Draw a diagram of the human ear and label the parts. Describe the function of each part.*

Materials

2 tuning forks (same frequency)	Small clamp
Resonance boxes	*Chart of human ear*

11. HOW ARE SOUNDS REFLECTED?

LABORATORY LESSON

Outcomes

- Waves striking hard, smooth surfaces are almost totally reflected.
- Waves striking soft, rough surfaces are absorbed and diffused.

Development

1. Explain that water waves are used in this experiment because they are easily produced and their behavior is similar to sound waves.
2. Demonstrate the proper way of producing a wave in the ripple tank with a slight motion of the ruler. (The ripple tank is simply a pan of water.)
3. Distribute materials and Worksheets.

   CAUTION: Pans should *not* be filled to the top. Students should be advised to produce small waves.

Summary

Refer to Worksheet.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 11

Problem: How are sounds reflected?

Materials

Ripple tank
(shallow pan, 6″ plastic ruler)

Paper towelling

Procedures and Observations

1. Fill the ripple tank (tray) half full of water.
2. Use the plastic ruler to produce a wave.
3. What happens to the wave when it strikes the hard, smooth surface of the ripple tank? ______________________________
   a. Draw and label a diagram of the wave and its echo.
4. Does the wave appear to lose energy upon striking the rear of the tank? ________________
5. Place some paper towelling or twisted cloth at the end of the ripple tank. Produce a wave.
6. What happens when the wave strikes the end of the tank? __________
   a. Draw and label a diagram of the wave and its echo.
7. Does the wave appear to lose energy upon striking the end of the tank? ________________

Summary

1. What are the reflected waves called?
2. Compare the waves produced by the hard smooth surface of the tray with those produced by the soft irregular surface.
3. What do you think happens to the energy in the wave when it strikes the *soft end* of the tank?
4. What effect does the rough surface of the tank have on the wave?
5. What type of wall should a room have if it is to produce strong echoes? Explain.
6. What should be done to the walls of a room to reduce echoes to a minimum?

Homework

1. Make a ripple tank (any rectangular tray with water will do). Using a plastic rule, start some small waves. What shape are the waves? What happens to them when they hit the end of the tank?
2. Allow one drop of water to fall into the center of the tank. What shape are the waves? What happens to the waves when they hit the end of the tank?
3. *What shape do you think sound waves have in air? Why?*

◆

REVIEW AND REINFORCEMENT (9-11)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Multiple Choice

1. A tuning fork of 256 hertz and another tuning fork of unknown frequency when struck at the same time produce four beats per second. The frequency of the unknown tuning fork is (a) 64 (b) 128 (c) 260 (d) 512.
2. The frequency of a vibrating string will depend upon the (a) amount of energy used (b) speed of sound through air (c) tension on the string (d) amplitude.
3. The quality of a sound depends upon the (a) pitch (b) loudness (c) frequency (d) size and shape of the vibrating body.
4. The speed of sound in air is approximately (a) 4800 feet per second (b) 4800 per minute (c) 1100 feet per second (d) 1100 feet per minute.
5. The pitch of a sound will depend upon (a) frequency (b) amplitude (c) volume (d) condition.
6. Sound travels fastest in (a) air (b) steel (c) vacuum (d) water.
7. Reflected sounds are called (a) vibrations (b) hertz (c) echoes (d) intense.

8. Underwater objects can be found using (a) sonar (b) rulers (c) charts (d) life preservers.

9. Of the following, the one that is *not* a stringed instrument is the (a) violin (b) drum (c) guitar (d) bass fiddle.

10. Echoes in an auditorium are *not* lessened by (a) cork ceilings (b) filling it with people (c) draperies on walls (d) good lighting.

Crossword Puzzle: Sound

It is suggested that the following puzzle be reproduced for student use. The answers have been provided for the instructor.

1 E	2 C	3 H	4 O	■	5 F	6 L	U	7 T	8 E
9 A	L	I	K	E	■	O	■	10 I	N
11 R	U	G	■	12 T	U	N	I	N	G
■	13 E	H	■	A	■	G	■	■	■
O	■	P	■	■	14 B	I	■	15 S	■
■	16 V	I	B	17 R	A	T	I	O	18 N
19 C	■	T	■	20 E	S	U	■	21 N	O
R	■	C	■	22 M	E	D	I	A	■
23 A	S	H	■	A	■	I	■	R	■
Y	■	■	24 S	P	25 I	N	■	■	26 C
O	■	27 T	O	■	28 T	A	29 R	■	P
30 N	E	O	N	■	■	31 L	E	N	S

Across

1. Reflected sound
5. Woodwind instrument
9. The same as
10. Preposition
11. Small mat
12. ________ fork
13. Exclamation
14. Prefix: meaning two
16. Repeated back and forth motion
20. Electrostatic unit: abbreviation
21. Negative
22. Plural of medium
23. Remains of burning
24. Rotate
27. Toward
28. Used for paving
30. Rare gas
31. Used to focus light

Down

1. Organ of hearing
2. Hint
3. Produced by rapid vibration
4. All right
6. Sound wave
7. Metal
8. Abbreviation for English
14. Turns red litmus blue
15. Underwater sound detection
17. Map again
18. Negative
19. Wax used for coloring
24. Male child
25. Preposition
26. Cycles per second: abbreviation
29. Note of scale

◆

LIGHT

Suggested Lessons and Procedures

12. HOW IS LIGHT DIFFERENT FROM SOUND?

Outcomes

- Light and sound are forms of energy.
- Sound requires a medium; light does not require a medium.
- The speed of light is much greater than the speed of sound.
- Light travels in straight lines.

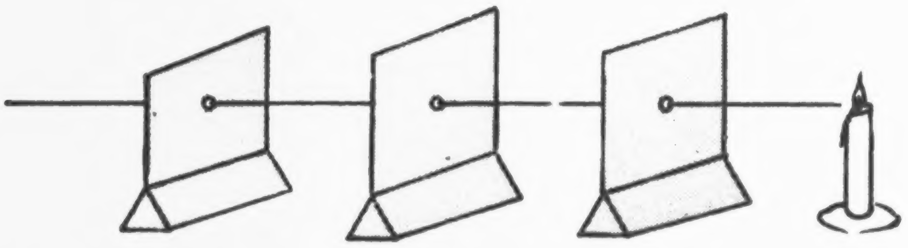
Motivation

Repeat the bell-in-vacuo demonstration. Simultaneously, shine a light through the vacuum.

Development

1. Ask the class what media may transmit sound. Elicit the need for a vibrating medium (air, glass, water, etc.).
2. Have the class discuss the medium through which light must travel to reach the earth from the sun. Refer to the bell-in-vacuo demonstration and establish that light does not require a medium.
3. Shine a light on a radiometer or place it in sunlight. Ask, "What is causing the vanes on the radiometer to turn?" Elicit that light is a form of energy.

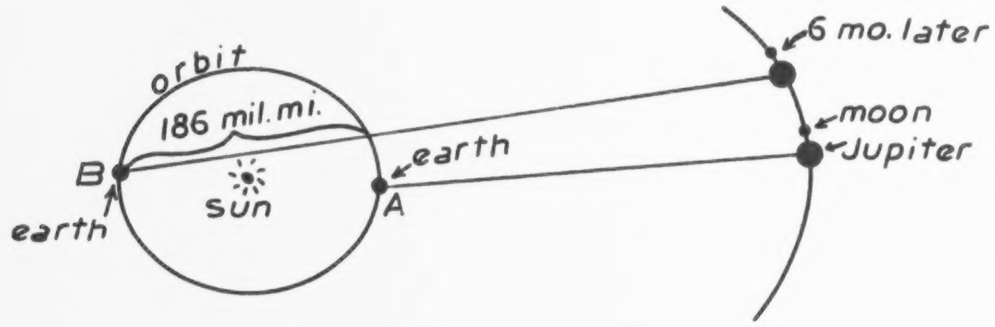
4. Demonstrate that light travels in straight lines by setting up the following:



Allow several pupils to observe that it is possible to see the candle only when the candle flame and the three holes are in a straight line. Vary the position of the cards so as to test this.

5. Refer to the lesson on the speed of sound and review the method used to measure its speed. Early attempts to measure the speed of light by the same methods failed because light travels at 186,000 miles per second, approximately one million times faster than sound.

6. *Present the following: In 1675, Ole Roemer, a Danish astronomer, devised a method to measure the speed of light. His source of light was one of the moons of the planet Jupiter.*



When the earth is at A, it is on that side of the sun nearest to Jupiter. The time for one complete revolution of Jupiter's moon was accurately known. From this knowledge, Roemer predicated that time (six months later) when the earth was on the opposite side of the sun (point B), that Jupiter's moon should just appear from behind the planet. The moon was 1,000 seconds later (about 17 minutes). Roemer assumed that this delay was due to the time it *took the light to travel the extra 186,000,000 miles from A to B. If you divide the diameter of the earth's orbit (186,000,000 miles) by the number of seconds it takes light to go across it (1,000 seconds), the speed of light can be found.*

$$\frac{186{,}000{,}000 \text{ miles}}{1{,}000 \text{ seconds}} = 186{,}000 \text{ miles/seconds}$$

Summary

1. Describe an experiment which shows that light is a form of energy.
2. How can we show that light travels in straight lines?
3. What evidence do we have that light can travel through a vacuum?
4. *Why was it necessary to use the astronomical distance to measure the speed of light?*

Homework

1. The circumference of the earth is 25,000 miles. How many times can light travel around the earth in one second?
2. List several similarities and differences between sound and light energy.

Materials

Bell in vacuo
Radiometer
Light source
Rubber tube

13. HOW DOES LIGHT TRAVEL?

Outcomes

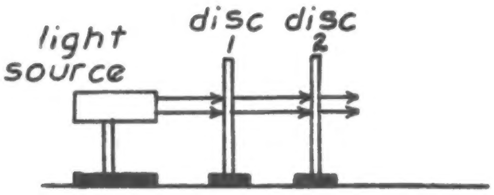
- Light travels in transverse waves.

Motivation

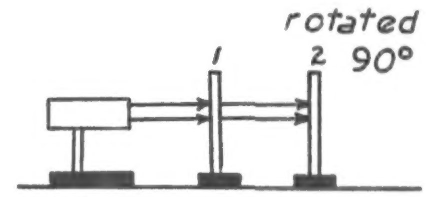
Fill a shallow pan with water. Drop a small piece of chalk into the center surface of the water so as to produce visible waves. Have the class observe and draw the shape of the wave produced. Identify these as transverse waves.

Development

1. Demonstrate the polaroid discs.



light passes through both discs



light does not pass through disc 2

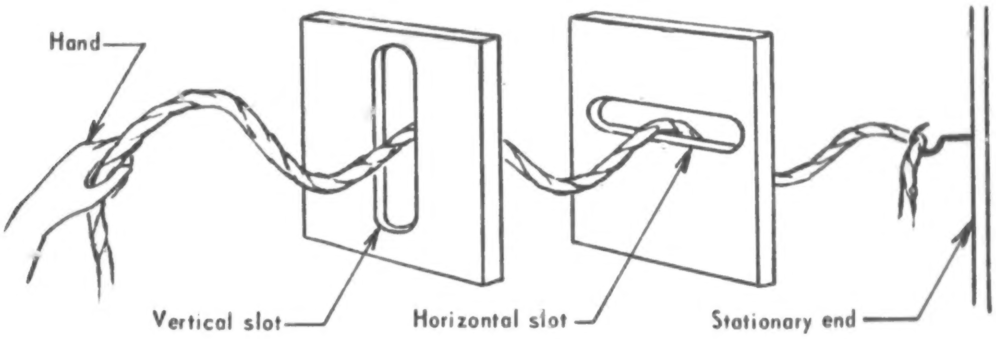
Slowly rotate the front disc and have the class note any unusual events. Have students raise their hands when they have made an observation.

NOTE: If standard polaroid discs are not available, the lenses from a pair of polaroid sunglasses may be used, or the material may be ordered from a local scientific supply house.

Do not explain how the polaroid discs work, but suggest that an investigation of the topic "How does light travel?" might supply the answers.

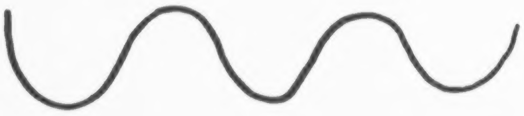
2. Review the fact that light is a form of energy. Develop in a discussion the concept that energy may travel in waves.

3. By use of a rope and two slotted cardboards (as shown), show that the rope may be vibrated transversely only when the slots are parallel. This may be done by slowly rotating one of the cardboards

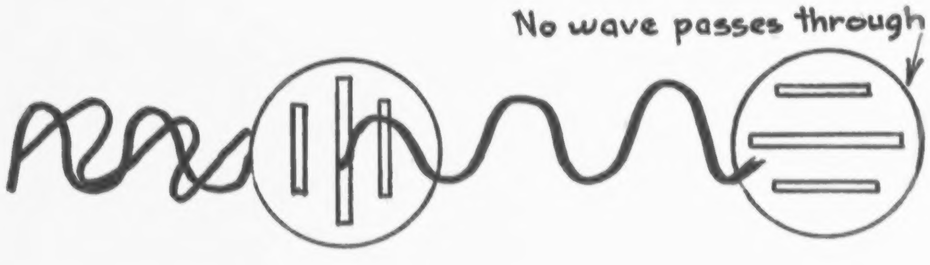


while a pupil tries to maintain a wave motion in the rope. Elicit that the amplitude of the wave is reduced when the slots are not parallel. Use this demonstration to illustrate the transverse nature of light waves.

4. Bend two wire hangers to represent transverse waves:

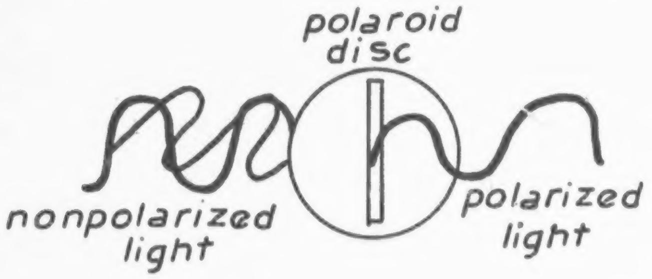


Use these to investigate the possibility that light is a transverse wave. By making predictions with the models and testing them with the actual discs, the class will see that a single transverse wave could be blocked by only one disc; but if the transverse waves are vibrating in many different planes, two discs are needed to block the light.



5. From the evidence assembled, the class should be encouraged to make the deduction that light behaves as a combination of many transverse waves. It is important to point out that what has been done was the construction of a theory to fit the observed behavior of light. A model has been made to explain the observations. Whether or not light really is a transverse wave has not been proved, but only that light behaves as if it were a transverse wave.

6. *Explain that light which has passed through only one of the polaroid discs is a special form of light. It is vibrating in only one*



direction and is called polarized light. The human eye is not able to tell the difference between polarized and non-polarized light.

Summary

1. What type of wave does light appear to be in the polaroid disc demonstration?

Homework

1. What has to be done to the polaroid discs to have them block the light?
2. Give an example of a transverse wave.
3. *How can you tell whether light is polarized?*

Materials

Polaroid discs

Cardboard

Wire hangers

14. WHAT IS PRODUCED WHEN LIGHT STRIKES AN OPAQUE OBJECT?

Outcomes

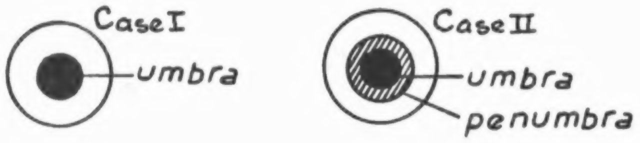
- When light strikes opaque materials, shadows are produced.

Motivation

Direct a beam of light from a point source onto a screen. (Placing a sheet of black construction paper with a small hole in it over a light source converts it into a point source.) Suspend a ping-pong ball between the light and the screen. Have the class observe the shadow produced. Repeat this procedure using an extended source of light. Have the class compare the two shadows produced.

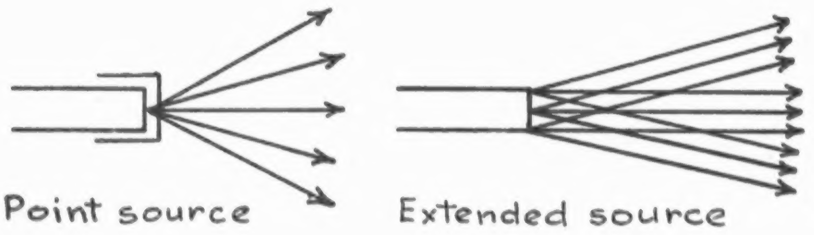
Development

1. Diagram the shadows produced in both cases and label as follows:

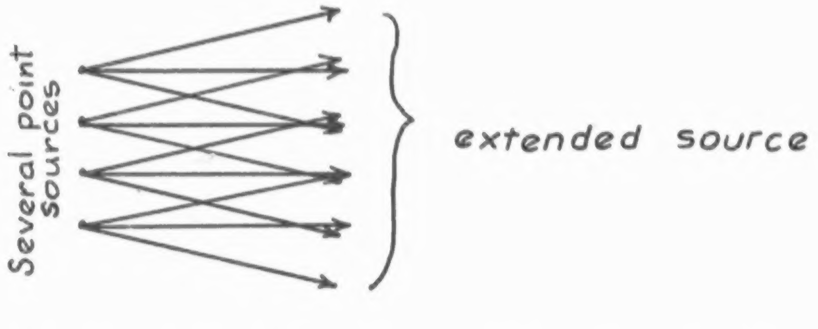

Case I
umbra
Case II
umbra
penumbra

Define the ***umbra*** as the darkest point of the shadow and the ***penumbra*** as the grey outer region. Define as opaque any material through which light cannot pass.

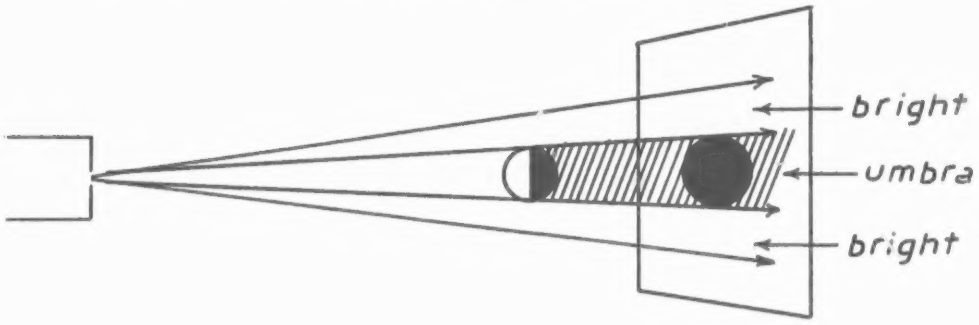
2. Draw the rays of light coming from the light sources and label them as shown.


Point source
Extended source

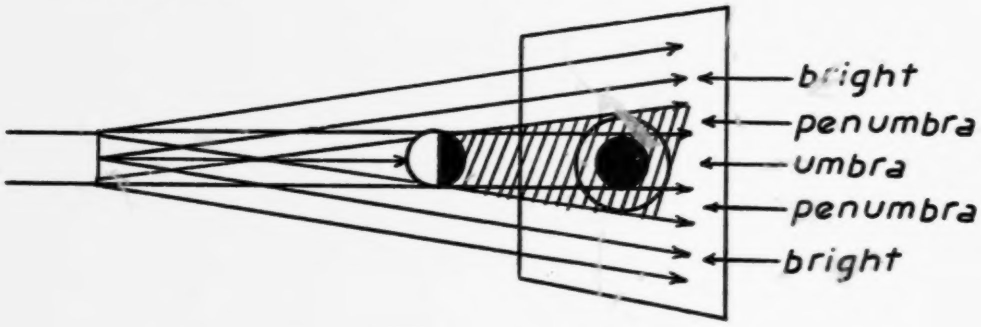
By drawing several point sources show how an extended source of light is composed of many point sources.


Several point sources
extended source

3. Review the fact the light travels in straight lines. Use this fact to analyze the shadow produced by the point source of light.

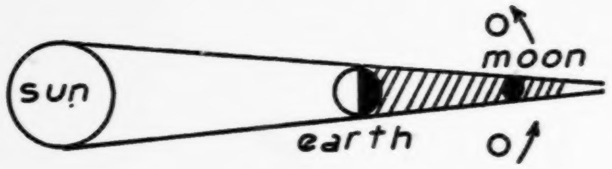

bright
umbra
bright

4. Using the same method, analyze the shadows produced by the extended source.

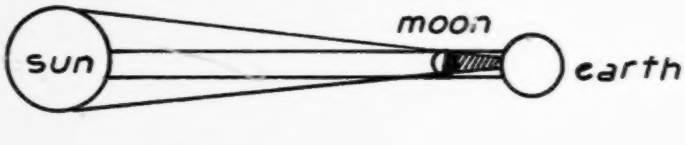


   a. No light reaches the umbra.
   b. Some light reaches the penumbra.
   c. Most light reaches the bright region.

5. Challenge the class to explain a total eclipse of the moon, based on what they have learned about shadows.



6. *Challenge the class to explain a partial eclipse of the sun, based on what they have learned about shadows.*



Summary

1. How is a point source of light different from an extended source?
2. What kind of shadow does a point source of light produce?
3. What kind of shadow does an extended source of light produce?

Homework

1. Observe the shadows produced by the sun. What kind of light source is the sun?

2. Draw a point source of light. What type of shadows will this light produce?
3. Draw and label a diagram showing how the umbra and penumbra of a shadow are produced.
4. *Account for a partial eclipse of the moon. Base your explanation on what you have learned about shadows.*

Materials

Light source	Screen	Ping-pong ball

15. HOW IS LIGHT REFLECTED FROM A PLANE MIRROR?

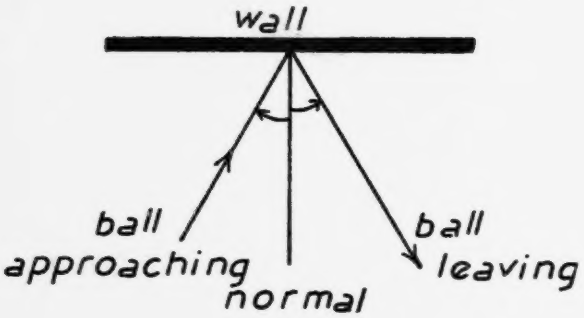
LABORATORY LESSON

Outcomes

- The angle of incidence (incoming ray) is equal to the angle of reflection (reflected ray).

Development

1. Tell the story of a handball player or a billiards player who wishes to hit the ball to a particular spot.
2. Challenge the class to suggest a method for measuring the angle made as the ball approaches the wall and after it leaves the wall.



Note: Define a *normal* as that line which makes a right angle (is perpendicular) to any given surface.

3. Distribute Laboratory Worksheets and materials. Guide the pupils in following the steps.

Summary

Refer to questions on Worksheet.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — PHYSICS: LESSON 15

Problem: How is light reflected?

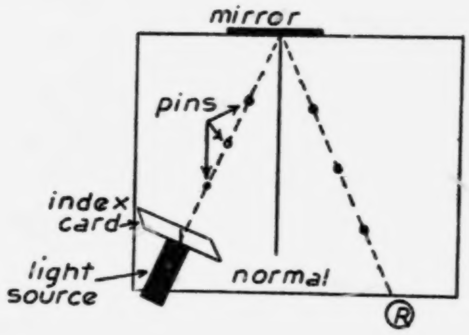
Materials

Protractor
Mirror
12″ ruler
Pins

Light source
Oaktag (11″ x 14″)
Index card (3x5), with a slit

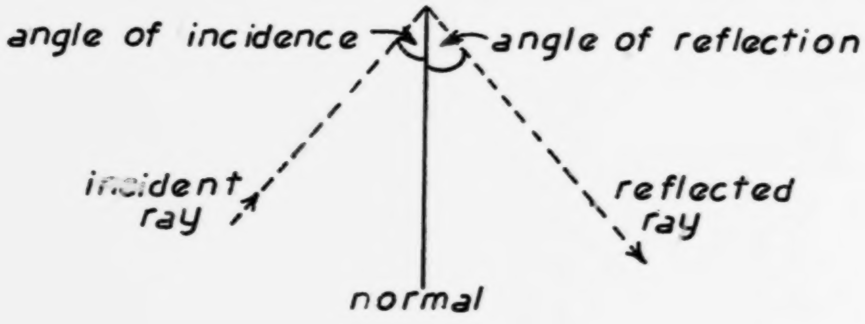
Procedures and Observations

1. Set up the following:
2. Stand the mirror at the back of the oaktag, facing you.



3. Using the protractor and ruler, draw a line that makes a 90° angle with the center of the mirror. (This line is the *normal.*)
4. Place the light source and index card, as shown, so that the ray of light strikes the mirror at the normal. (Have your teacher check this before you continue.)
5. Place several pins along the line made by the beam of the incoming (incident) ray.
6. By placing your eyes just above the level of the paper at point R, look at the mirror and sight until you see the slit of the index card in line with the mirror.
7. Place several pins along this imaginary line.
8. Remove the mirror and light source and with your ruler, draw a straight line connecting the pins of the incoming ray. Repeat this with the pins for

the reflected ray. (The angle between the incoming ray and the normal is called the angle of incidence. The angle between the normal and reflected ray is the angle of reflection.)



9. Using your protractor, measure the angle of incidence and the angle of reflection. (Each of these angles is measured *from* the normal.)
10. Repeat this procedure several times, each time changing the angle of the incoming ray with the normal.

Summary

1. What is the incident ray?
2. What is the reflected ray?
3. Define the normal.
4. What is the angle of incidence?
5. What is the angle of reflection?
6. State the Law of Reflection.

Homework

1. Draw a diagram illustrating the law of reflection.
2. A ray of light strikes a mirror at an angle of incidence of 32°. Draw and label the incident ray, the normal, the reflected ray, the angle of incidence, and the angle of reflection.

◆

REVIEW AND REINFORCEMENT (12-15)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Films and Filmstrips*

Sound. 9 min. Gateway, 1951

Simple experiments show how vibrations are made, how sound waves are carried, and how the human ear receives these waves.

Sounds All About Us 11 min., Coronet, 1954

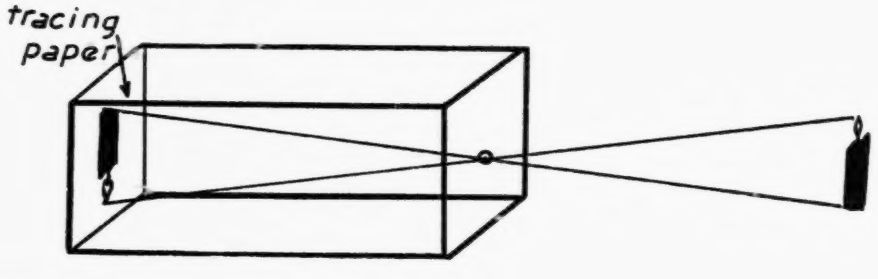
Through experiments with a tuning fork, we discover that sounds are caused by vibrations or movements of different objects. Various sounds children will recognize demonstrate that sounds differ in pitch, loudness, and quality.

Topics for Reports

1. Christian Huygens
2. Isaac Newton
3. Ole Roemer
4. Albert Michelson

Discussion and Demonstration

1. Demonstrate the Hartl Optical Disc or Blackboard Optics Kit to illustrate the law of reflection. Demonstrate the angle of incidence and the angle of reflection of several different positions.
2. Demonstrate the pinhole camera to reinforce the concept that light travels in straight lines.



---

* See footnote on page 22.

◆

16. WHAT ARE SOME CHARACTERISTICS OF A PLANE MIRROR IMAGE?

Outcomes

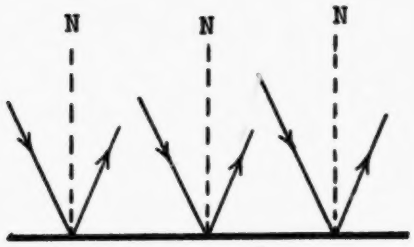
- **Reflection of light may be regular or diffuse.**
- **Plane mirror images are erect, same size as object, and reversed.**

Motivation

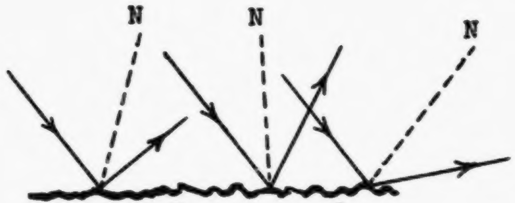
Mount a large sheet of aluminum foil with the polished side facing outward. Allow several students to observe their reflections on the mirror-like surface. Remove the aluminum foil, crumple it, and carefully flatten it and again allow several students to observe their reflections.

Development

1. **Challenge the class to account for the fact that no image is produced on the crumpled aluminum foil.**
2. **Review the law of reflection and encourage the class to use their knowledge to explain what they observed earlier. The following may be placed on the chalkboard:**

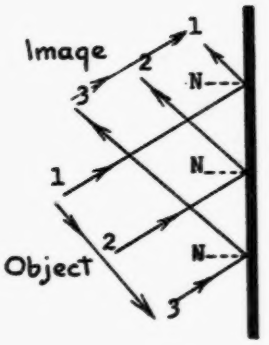


Polished surface
REGULAR REFLECTION



Rough surface
DIFFUSE REFLECTION

3. **Display a large mirror and place a paper arrow about 7 inches in front of it.**
4. **Have the pupils list their observations with respect to size, distance, erect image or inverted, and position (reversed or normal).**
5. ***Challenge the class to account for the reversal of a plane mirror image. The following will prove helpful:***



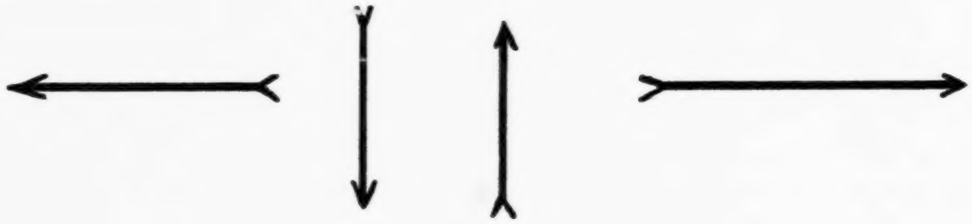
The crossing of light rays as they are reflected from a plane mirror causes the reversal of the image.

Summary

1. How could a scratched piece of metal be changed into a mirror?
2. What type of reflection do you get from a rough surface?
3. What are three properties of a plane mirror image?

Homework

1. By using a diagram, compare how light is reflected from a smooth and a rough surface.
2. How would the following look if reflected by a plane mirror?



Materials

Aluminum foil

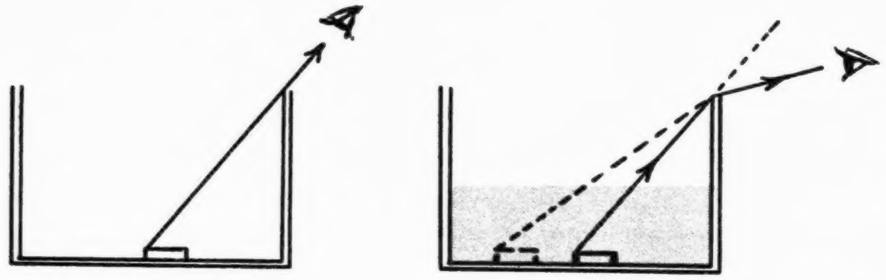
17. HOW CAN LIGHT BE BENT?

Outcomes

- A ray of light bends (is refracted) when it travels from one transparent medium into another.

Motivation

Place a coin to one side in an opaque container and arrange some pupils around it so that the coin is not visible because of the walls of the container. Have a pupil pour water into the container slowly. As the water level rises, the pupils will be able to see the coin.



Development

1. Elicit from the class:
   a. The coin is not visible at first because light travels in straight lines and is blocked by the sides of the tray.
   b. The light must have bent for the coin to have become visible when the water was added.
   c. The light must have bent because of the water.
   d. The light bent at the surface of the water.
   e. Because the light coming from the coin was bent, the coin appears to have changed position.
2. Challenge the class to give other examples of instances where objects are not where they appear to be.
3. Demonstrate the path of light during refraction using a plane glass with the Hartl Optical Disc or the Blackboard Optics Kit. The same results may be obtained by shining a light through an aquarium tank filled with an eosin-water solution.
4. Have the class make observations of the path of the light and establish the following generalizations:
   a. When light passes from one medium to another obliquely (at an angle), it is bent.
   b. When light passes from one medium to another along the normal (strikes the surface perpendicularly), it is not bent.

5. Define refraction as the bending of light at an angle as it passes from one medium to another.

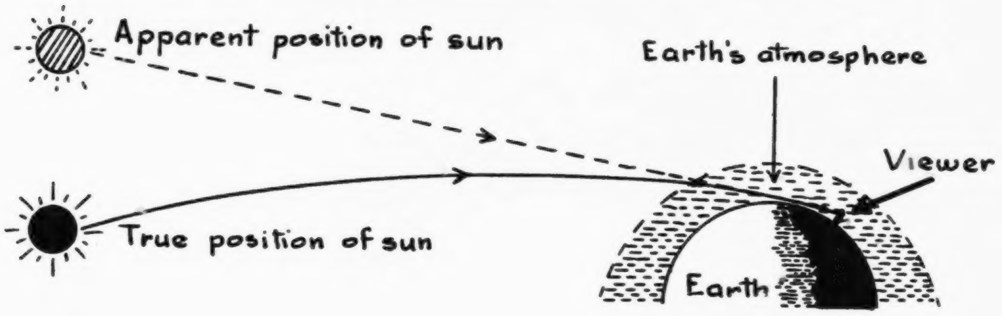
6. *Discuss any of the following applications of refraction that are within the experiences of the pupils:*

   a. mirages

   b. twinkling of stars

   c. misjudgment of the position of objects in water

   d. seeing the sun and moon a short time before they actually rise (due to the bending of their light in the atmosphere).



Summary

1. What happens to light when it passes from one medium to another: a. At an angle? b. Along the normal?

2. Where does light bend when it passes from one medium to another?

3. Define refraction.

Homework

1. Draw and label a diagram showing why the coin became visible when water was poured into the tray.

2. If you observed the coin from a position directly above, would it appear in its actual position? Explain.

3. When you look at tropical fish in an aquarium, do you see the fish in their actual positions? Explain.

4. Based on refraction, explain any one of the following:

   a. mirages b. twinkling of stars

c. misjudgment of the position of objects in water

d. seeing the sun and moon before they actually rise.

Materials

Hartl Optical Disc	Tray	Coin

18. HOW CAN REFRACTION BE EXPLAINED?

Outcomes

- When light travels at an angle from a less dense medium into a more dense medium, it is bent toward the normal.
- When light travels from a more dense medium at an angle into a less dense medium, it is bent away from the normal.

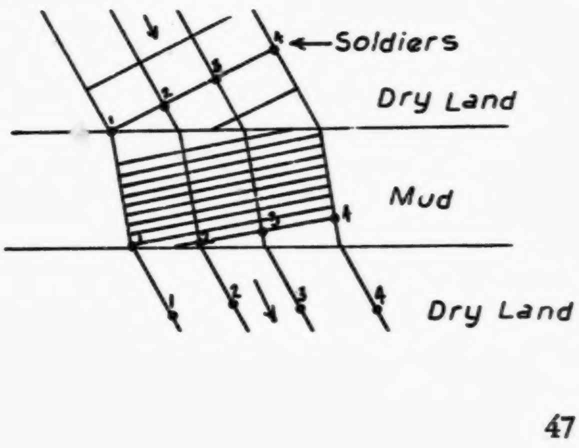
Motivation

After filling a battery jar with water, drop a paper clip or some other object with a very small mass into the jar from a height of about 2 feet. Repeat this several times. Ask the class to observe what happens.

Development

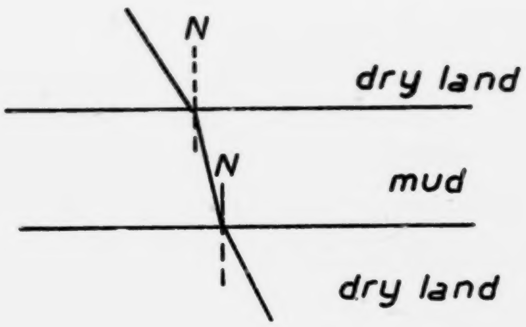
1. Challenge the class to explain why the speed of the paper clip is less as it travels through the water. (Review the concept of density as covered in the eighth year.)
2. Have the class visualize a column of soldiers (4 abreast) marching in cadence obliquely into a muddy area and then out on to hard, dry land again.

   Develop the following diagram, step by step:



3. Elicit that:
   a. Upon entering the mud, soldier number 1 is slowed down while the rest of them still move at normal speed.
   b. By the time soldier number 4 has reached the mud, the column has turned and now all four are marching at the same slower speed in a new direction.
   c. When soldier number 1 reaches dry land again, he resumes normal speed while the rest are still marching at the slower speed.
   d. When soldier number 4 reaches the dry land, the column has returned to its original direction and speed.

4. Focus the attention of the class on soldier 1 and draw his path.



Elicit from the class that his path is bent toward the normal when he enters the more dense medium (mud) and away from the normal when he passes from mud to dry land.

5. Suggest to the class that the marching soldiers could represent a light wave, the dry land—air and the mud—glass. Use the Hartl Optical Disc or the Blackboard Optics Kit to find out whether the predictions about the soldiers are also true about light waves.

6. Establish the following as generalizations:
   a. When light passes from a less dense to a more dense medium, it is bent toward the normal.
   b. When light passes from a more dense to a less dense medium, it is bent away from the normal.

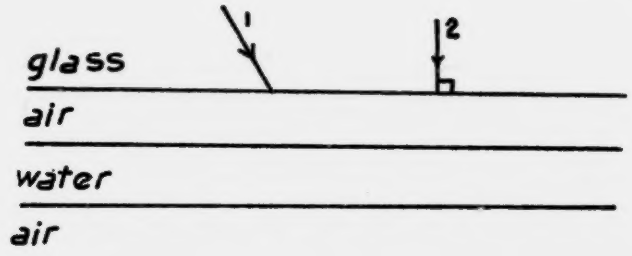
7. Demonstrate, with the Hartl Optical Disc, that when light passes from one medium to another *along the normal,* it is not refracted (bent).

Summary

1. What happens when light passes from a more dense material (such as water) into air (a less dense material)?
2. What happens when light passes from a less dense material into one which is more dense?
3. A light may pass from a less dense material into a more dense material without being bent. Explain.

Homework

1. Describe some of the problems that Indians, fishing with bow and arrow, might have.
2. For the diagram, complete the paths for Ray 1 and Ray 2. (Include the normals.)



Materials

Battery jar

Paper clips

Water

19. HOW DOES A CONVEX LENS AFFECT LIGHT?

Outcomes

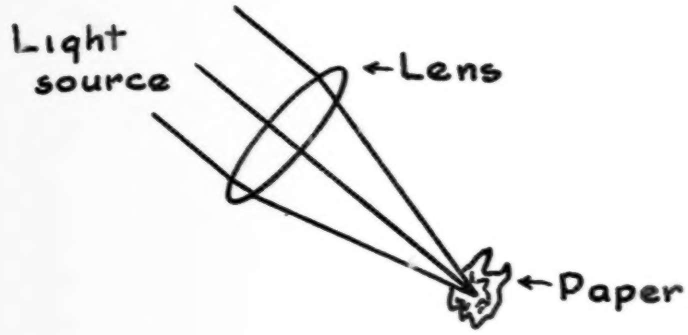
- A convex lens converges light to a focus.
- A convex lens produces a magnified image.

Motivation

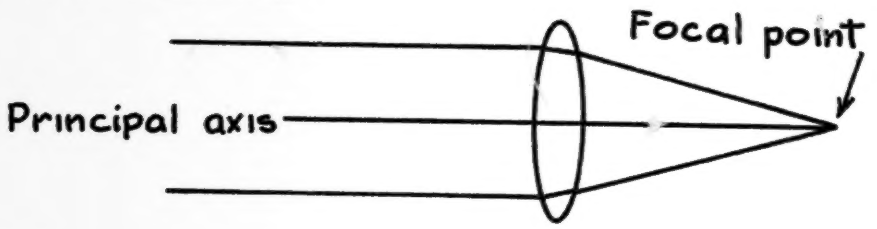
Lenny, Stanley, and Sam were on a camping trip. They lost their matches and wanted to build a fire. Sam looked at his wristwatch and said: "I can start the fire!" How is he going to do this?

Development

1. Encourage a class discussion about what Sam did. If the correct answer is not suggested, give the following hint: "How many of you have ever seen a magnifying glass used to start a fire?"
2. Develop with the class that a convex lens brings all of the light rays together. The point at which they meet is called the focus, or focal point. Place the following on the board:



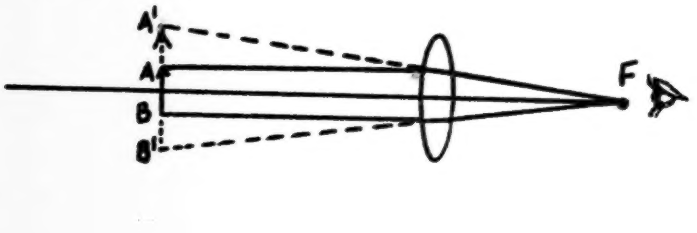
3. Using the Hartl Optical Disc or the Blackboard Optics Kit, demonstrate the convergence of light by a convex lens.
4. Develop the following:



   a. The principal axis is that line which is perpendicular to both sides of the lens. Light passing along the principal axis is not refracted.

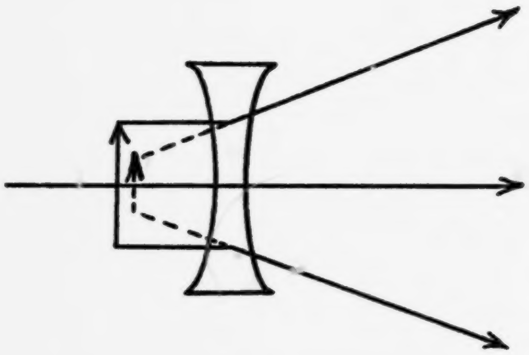
   b. By applying previously developed rules of refraction show how the other light rays are refracted toward the point of focus (focal point).

5. Magnification may be explained as follows:



When the object AB is viewed from F, the light appears to be coming from A'B' and so the object appears larger than it actually is. This happens because our eyes see only the direction from which the light appears to be coming.

6. *Draw a cross section of a concave lens on the chalkboard.*



Challenge the class to predict how light will behave when it passes through the lens. Check the predictions using the Hartl Optical Disc or the Blackboard Optics Kit. The following generalizations may be drawn:

a. a concave lens diverges light

b. a concave lens diminishes the size of the image.

Summary

1. What effect does a convex lens have on light?
2. What is the principal axis of a lens?
3. What is the point called where all the light rays converge?

Homework

1. Draw a diagram of light passing through a convex lens. Label the following: a) focus, b) principal axis.
2. On a diagram, show how an image is magnified by a convex lens.
3. *Draw a diagram of light passing through a concave lens. Show, on this diagram, why a concave lens diminishes the size of images.*

Materials

Hartl Optical Disc	Convex Lenses
Blackboard Optics Kit	*Concave Lenses*

20. WHAT ARE SOME PROPERTIES OF A CONVEX LENS?

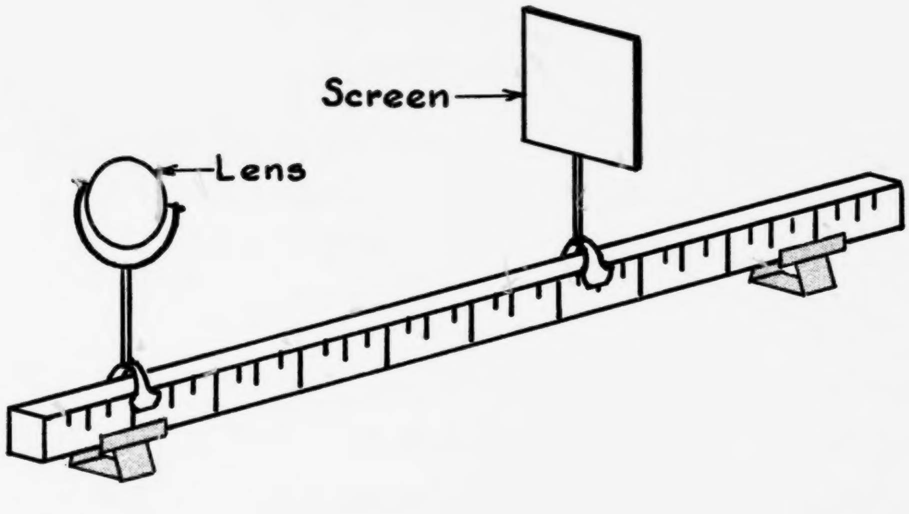
LABORATORY LESSON

Outcomes

- A convex lens forms an inverted image.
- A convex lens forms a real image.

Development

1. Demonstrate the proper method for setting up the Meterstick Optical Bench. (If the clips are not available, the lens and screen may be mounted in clay blocks.)



2. Distribute Worksheets and materials.

   NOTE: This investigation must be done in a darkened room.

Summary

Refer to questions on Worksheet to reinforce concepts.

(MAY BE DUPLICATED FOR USE BY PUPILS)

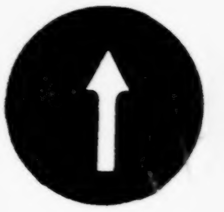
LABORATORY WORKSHEET — PHYSICS: LESSON 20

Problem: What are some properties of a convex lens?

Materials

Meterstick	Light source [flashlight]
Convex lenses	Mask for light source
Small screen	Scissors or single-edged razor blade
Clips	Scotch tape

Procedures and Observations



1. Set up your optical bench as demonstrated by your teacher.

2. Cut a small arrow in a piece of cardboard and tape it over your light source.

3. Hold the light source about 100 cm (40 inches) from the convex lens. Have another member of your lab group move the screen back and forth until a clear image of the arrow appears on the screen. An image that can be focused on a screen is called a real image.

4. Move the light source closer to the lens and adjust the position of the screen until a clear image is produced. Repeat this several times.

5. What observation can you make about the position of the arrow in each case? A convex lens produces an *(erect, inverted)* ________________ image.

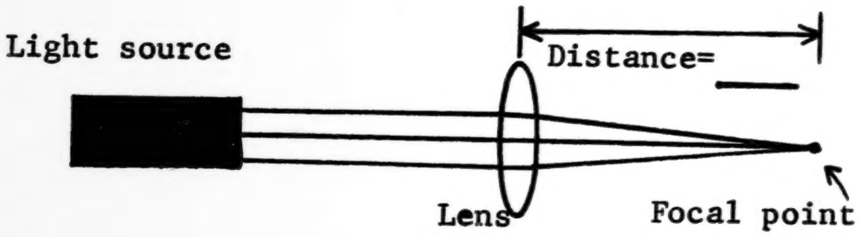
6. Place the light source about 50 cm (20 inches) from the lens, and move the screen until a clear image is formed. Measure the distance from the lens to the screen. Repeat this measurement several times.

   Measurement 1. ________________ 3. ________________

   2. ________________ 4. ________________

   Average distance ________________

7. Fill in the distances on the following diagram. Use the information you obtained in item 6.



The distance from the focal point to the lens is called the focal length. The focal length of the convex lens used in the experiment is ________________.

Summary

1. What type of image is formed by a convex lens?
2. Define focal length.

Homework

1. List three optical instruments that magnify.
2. Why was it important to get an average focal length?

REVIEW AND REINFORCEMENT (16-20)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Discussion and Demonstration

1. Microscope
2. Telescope
3. Periscope
4. Binoculars
5. Camera

Suggested Project: The Periscope

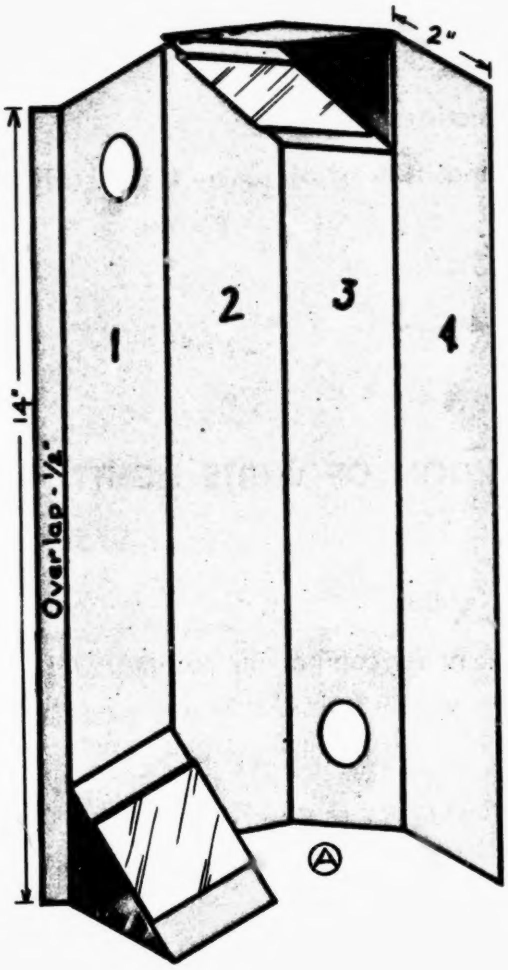
Materials

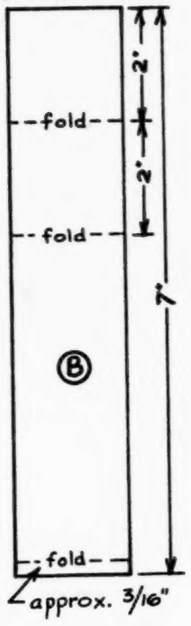
Oaktag 8″ x 14″
2 strips oaktag — 2″ x 7″
Scotch tape
Paper
Glue
2 mirrors — 2″ x 2″

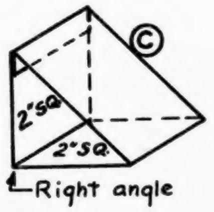
Procedure

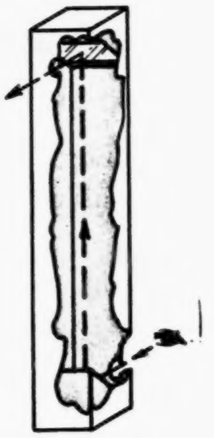
1. Fold oaktag into 4 sections, 2″ wide and ½″ overlap as shown in A.
2. Unfold and number each of the faces. (See A.)
3. Cut circles of approximately 1″ diameter as shown.

4. With strips of oaktag, construct right angle prisms having two faces that are 2″ square. (See B and C.)

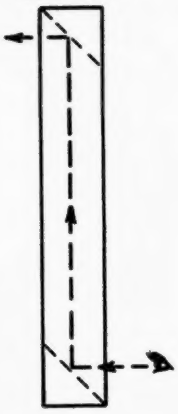

2″
14″
Overlap - 1/2″
1
2
3
4
Ⓐ


2″
2″
2″
fold
fold
fold
7″
Ⓑ
approx. 3/16″


Ⓒ
2″SQ.
2″SQ.
Right angle



Side view



5. Glue triangles as shown in A.

6. Glue 2″ x 2″ mirrors as shown.

7. Fold and tape.

Summary

Have the pupils state the laws of reflection and trace the path of light through the periscope.

Topics for Reports

1. Electron Microscope
2. Galileo Galilei and the Refracting Telescope
3. Anton Van Leeuwenhoek and the Simple Microscope
4. Sir Isaac Newton and the Reflecting Telescope
5. Joseph Priestly and the Decomposition of Mercuric Oxide (HgO) with a Magnifying Glass

◆

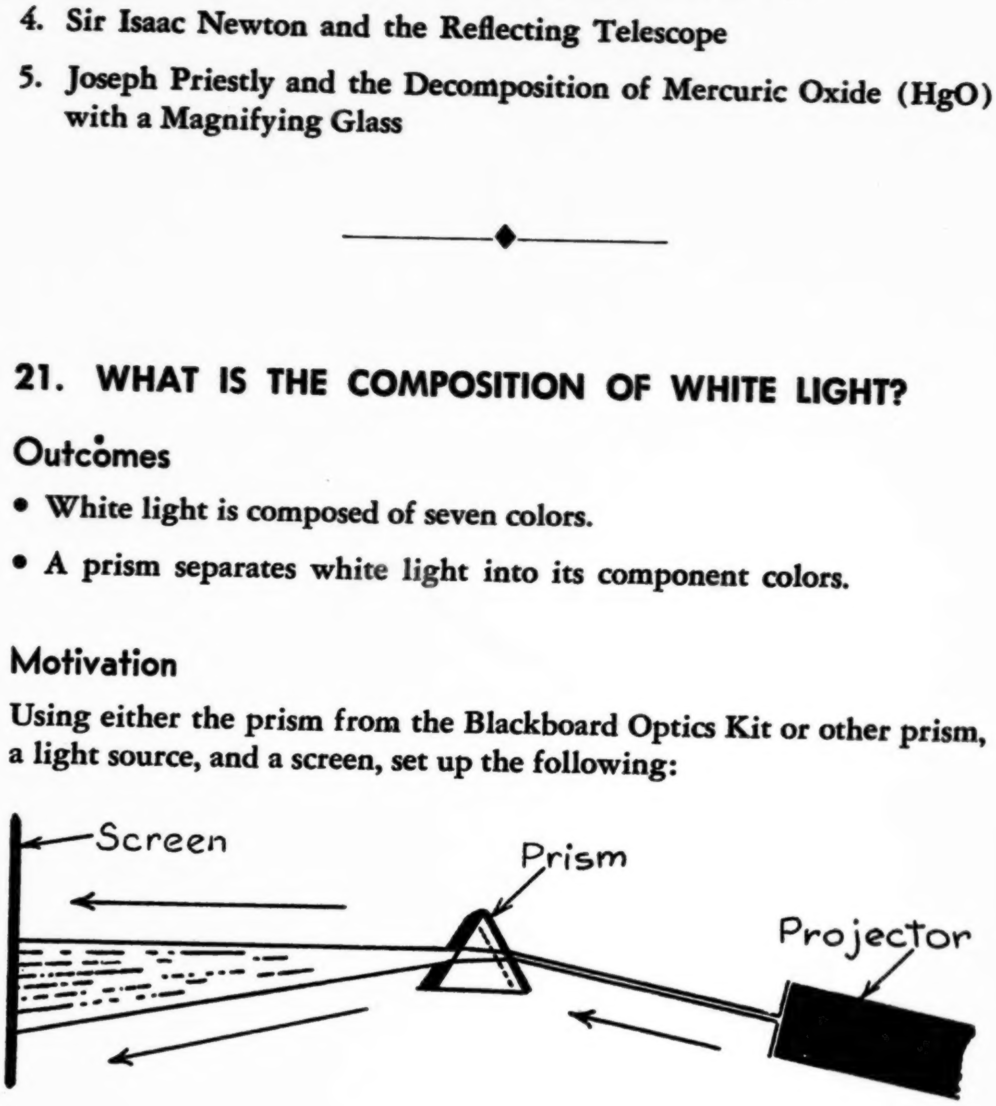
21. WHAT IS THE COMPOSITION OF WHITE LIGHT?

Outcomes

- White light is composed of seven colors.
- A prism separates white light into its component colors.

Motivation

Using either the prism from the Blackboard Optics Kit or other prism, a light source, and a screen, set up the following:



Development

1. Ask the class to observe the phenomenon and report their observations.
2. Ask, "From where are the colors coming?" Elicit from the class that the prism, being colorless, could not be adding color to the

white light. Challenge the class to account for the spectrum (band of colors).

3. Have the class draw the apparatus in their notebooks.

   Note: A pupil volunteer may be asked to draw and label a diagram, using colored chalk, at the chalkboard.

4. Have a pupil identify the sequence of colors that appear on the screen. These are called the colors of the ***visible spectrum.***

   red
   orange
   yellow
   green
   blue
   indigo
   violet

   Roy G. Biv is a helpful mnemonic device.

5. Have the class restate and review the laws of refraction (refer to previous lesson).

6. Applying the laws of refraction, have the class trace a beam of white light as it passes through a prism. Modify the diagram to demonstrate the dispersal of white light into its component parts.

7. Challenge the class to account for the ordered appearance of the colors of the visible spectrum. Guide the class to the generalization that because of the prism different colors are refracted through larger or smaller angles of refraction. (Red undergoes the least refraction, violet the greatest.) The order of appearance is determined by the differences in angles of refraction of each color.

8. *Challenge the class to account for the appearance of a visible spectrum in a rainbow. Rainbows appear after rainstorms when water droplets are suspended in the air. Each water droplet acts as a small prism.*

9. *Fill a Petri dish halfway with water. Dip a needle into any lightweight motor oil. Touch the needle to the surface of the water so as to produce a thin film. Have the class observe and account for the resulting phenomenon.*

   Note: *The success of this demonstration is dependent upon the thinness of the oil film.*

Summary

1. How could you show that white light is composed of colors?
2. Name the colors of the visible spectrum in their proper order.
3. Which color is refracted the most when it passes through a prism? Which is refracted the least?

Homework

1. Draw a diagram to illustrate the passage of white light through a prism.
2. Sir Isaac Newton recognized the relationship between white light and its component colors. Go to the library and find out:
   a. When did Newton live? Where?
   b. What did Newton think light was?
   c. What else did Newton discover?

22. WHY DO OBJECTS APPEAR TO HAVE COLOR?

Outcomes

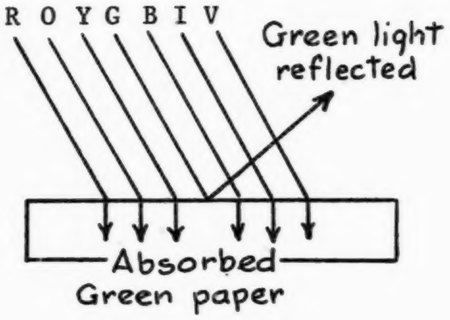
- The color of an opaque object depends upon the colors it reflects.
- The color of a transparent object depends upon the colors it transmits.

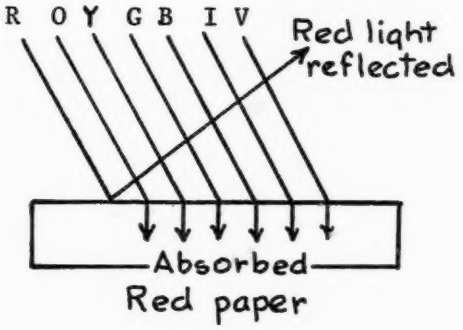
Motivation

In a darkened room, turn on a red colored light. Let it shine on a number of brightly colored objects. Have the class attempt to describe the colors.

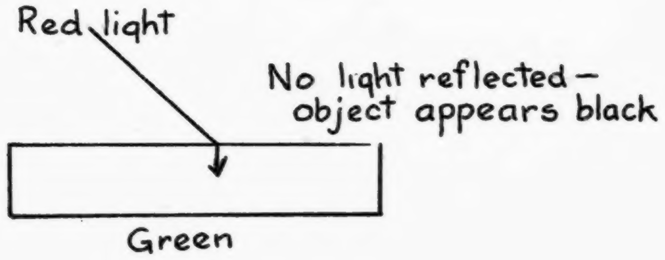
Development

1. Show the objects in ordinary light.
2. Using the following diagram, establish the generalization that objects are the color they reflect.


R O Y G B I V
Green light reflected
Absorbed
Green paper


R O Y G B I V
Red light reflected
Absorbed
Red paper

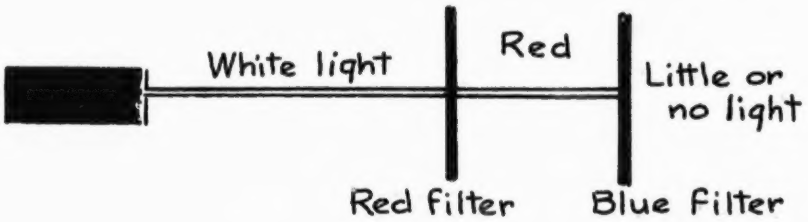
3. Using this information, challenge the class to explain why the objects in the previous demonstration appeared black. Develop with the class that since no light was reflected, the object appeared to be black.


Red light
No light reflected — object appears black
Green

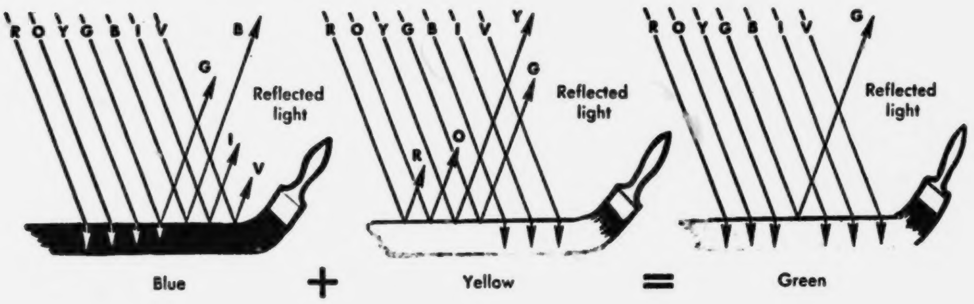
4. Similarly, have the class account for the white object appearing red.

   NOTE: A white surface will reflect all the colors of the visible spectrum.

5. Using a light source and filters, demonstrate that filters selectively transmit colors. (A red filter allows only red light to pass through.)
6. Allow white light to pass through a red filter. Have the class observe that the transmitted light is red. Have the class predict the effect of placing a blue filter in front of the red.
7. The following diagram may be used to account for the observed phenomenon.


White light
Red
Little or no light
Red Filter
Blue Filter

8. *Display small jars of yellow and blue paint. Mix them together in a container and have the class predict the color that will result. (Green.) The phenomena may be explained using the following diagram:*


R O Y G B I V
B
G
I
V
Reflected light
Blue
+
R O Y G B I V
Y
G
O
R
Reflected light
Yellow
=
R O Y G B I V
G
Reflected light
Green

If you mix thoroughly two paints such as blue and yellow, the resulting color will be green. This is the only color reflected by the mixture of both paints.

Summary

1. What color do green objects appear under green light?
2. Some materials have the ability to reflect all colors. What color is the material?
3. A filter has the ability to transmit all colors. What color is it? Give an example. (Cellophane, plate glass.)

Homework

1. Explain the green color of green glass. What happened to all the other colors?
2. Explain the green color of green paint. What happened to all the other colors?

Materials

Light source
Colored cellophane filters
Various colored objects
Yellow and blue paint
Beaker

23. WHAT PARTS OF THE SPECTRUM COME BEFORE RED AND AFTER VIOLET?

Outcomes

- The color of light is determined by its wavelength.
- Certain materials fluoresce when exposed to ultraviolet light.
- Infrared light is a radiant form of heat energy.

Motivation

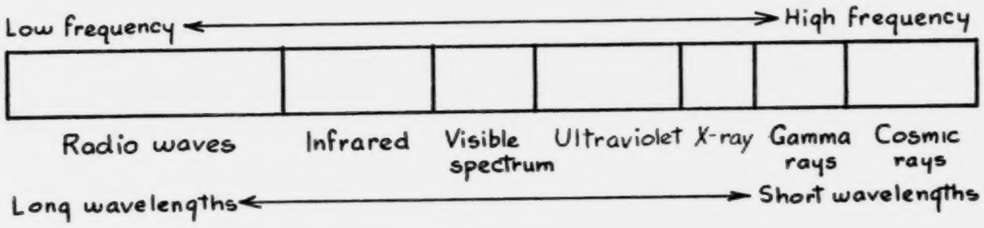
Select several specimens of fluorite, calcite, scheelite, willemite and sphalerite. Darken the room and illuminate each of the specimens with a white light source covered with a piece of violet cellophane. Repeat this using an ultraviolet light source.

CAUTION: Make certain that students do not see directly the source of the ultraviolet light.

Challenge the class with, "Are both light sources the same?"

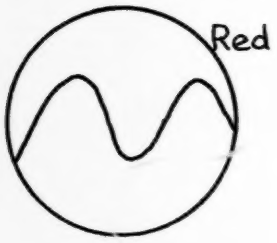
Development

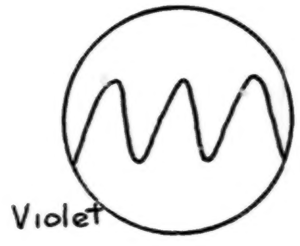
1. Elicit from the class that although the color of the light coming from both sources appears to be the same, the light causing fluorescence must be different.
2. Identify the invisible rays as ultraviolet rays.
3. Refer to grade 8 Earth Science to review that ultraviolet is a component of sunlight, and does not reach the earth's surface due to the action of the ozone layer.
4. Place the following diagram on the chalkboard:


Low frequency
High frequency
Radio waves
Infrared
Visible spectrum
Ultraviolet
X-ray
Gamma rays
Cosmic rays
Long wavelengths
Short wavelengths

NOTE: Add the labels as you develop different portions of the spectrum.

5. Review the concept of light acting as a wave. Develop with the class the idea that waves can be described by their length. The following may be useful:





6. Based upon the diagram, establish that red light is composed of longer waves than violet light.

7. Challenge the class to consider the possibility of light waves which are longer than red and shorter than violet. Label ultraviolet and infrared on the chart.

8. Using an infrared lamp and an ordinary light source covered with a red filter, demonstrate the invisible infrared rays by shining both lights on any metallic surface (aluminum cafeteria tray). The pupils will soon note that the part of the tray exposed to the infrared is considerably warmer.

9. For discussion, select from the following table those differences and similarities between ultraviolet, infrared, and visible light within the experiential background of the class.

	VISIBLE	REFLECTED	REFRACTED	CAUSE OF SUNBURN	STRONG HEATING EFFECTS	PENETRATE WINDOW GLASS
Visible Light	Yes	Yes	Yes	No	No	Yes
Ultra-violet	No	Yes	Yes	Yes	No	No
Infrared	No	Yes	Yes	No	Yes	Yes

10. *Extend the drawing of the spectrum to include radio, X-rays, gamma rays, and cosmic rays.*

Summary

1. Which has a longer wavelength, red or violet light? Explain.

2. Can you see the light that gives you a sunburn? Explain.
3. How can we show that infrared light is a form of heat energy?

Homework

1. What form of light energy is given off by a toaster?
2. What type of light is given off by a regular light bulb? How do you know?
3. Explain why you can't get a sunburn through window glass.

Materials

Light source
Red filter
Violet filter
Fluorescent minerals
Infrared lamp
Ultraviolet lamp
Metal tray

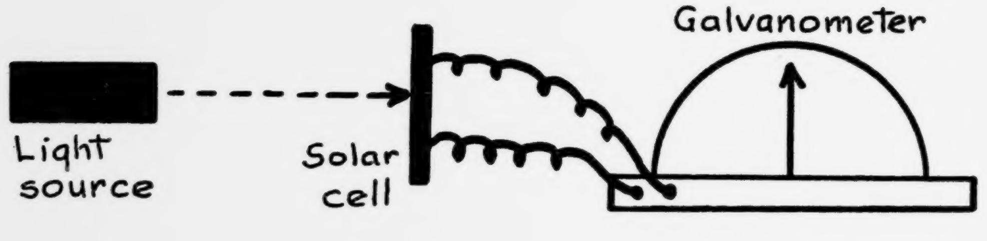
24. HOW CAN LIGHT ENERGY BE CHANGED INTO OTHER FORMS OF ENERGY?

Outcomes

- Some materials produce an electric current when struck by light.
- Light can cause a chemical change.
- *When light produces electricity, it is acting as a particle.*

Motivation

Set up the following:



Turn on the light source and have the class observe the movement of the galvanometer needle.

Note: If a solar cell and motor combination is available it makes a more dramatic demonstration.

Development

1. Challenge the class to account for their observations. Elicit that light energy is being changed directly into electrical energy.

2. Identify this phenomenon as the photoelectric effect. Explain the origin of the word photoelectric (light-electricity).

3. Demonstrate and discuss such applications of the photoelectric effect as the: (a) light meter (b) electric eye (c) solar cell in satellites.

4. Prepare two test tubes of silver nitrate solution. Cork both test tubes and place one in a box (to prevent exposure to light). Expose the other test tube to strong light. Have the class note the reaction in the exposed tube and the lack of change in the protected tube. Establish that light energy is being changed into chemical energy.

5. Expose a radiometer to strong light. Have the class note the conversion of light energy into mechanical energy.

6. Refer to the 8th grade physics unit to review the concept of conservation of energy.

7. *Offer the following as an explanation of the photoelectric effect: In the photoelectric effect, light acts as if it were a particle. These particles are called photons. When photons strike a sensitive surface they cause the electrons to move, thus producing an electric current.*

Summary

1. How can you show that light is a form of energy?

2. What effect is responsible for the operation of the solar cell?

3. What principle is illustrated by the conversion of light energy to other forms of energy?

Homework

1. How could you use an electric eye to protect your home?

2. How does photographic film make use of a chemical change caused by light?
3. *Report on Albert Einstein and the photoelectric effect.*

Materials

Light source	Two test tubes and rack
Solar cell	Silver nitrate solution
Galvanometer	Rubber stoppers
	Radiometer

◆

REVIEW AND REINFORCEMENT (21-24)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Topics for Reports

1. Electron Microscope
2. The Laser in Holography, Communications, Medicine
3. Maser
4. Spectroscope
5. Spectrophotometer
6. Doppler Effect
7. Radio Telescopes
8. Roentgen X-Ray

Films and Filmstrips*

Light and Heat. 9 min., Gateway, 1951

The sources of reflected and refracted light as well as the transmission of light and reflection are described, and the principles tested.

---

* See footnote on page 22.

Sound Waves and Stars: The Doppler Effect. 12 min., color, Film Association of California

Why does the sound of a passing train suddenly change as the train passes by? Christian Doppler, scientist, was curious about this change. He found that the waves ahead of a moving source increase in frequency, while the frequency of the waves behind such a source decreases.

Spectrograph. 20 min., color, Contemporary, 1948

Nature and principles of the spectrograph and its applications in industry, research, art, and astronomy.

Suggested Demonstrations

Color by Reflection

No object, however brightly colored, can reflect colors not present in the available light. This can be demonstrated in a darkened room using a color photograph. As a light source select a few crystals of borax (sodium borate) or rock salt (sodium chloride). Place these on a screen atop a tripod. Light the Bunsen burner. In the yellow sodium light you cannot recognize any colors but yellow.

This demonstration may be repeated using large crystals of copper sulfate. The flame will be green and all colors but green will be unrecognizable.

◆

PHYSICS UNIT REVIEW

Tests

Multiple Choice

1. Sounds are produced by a) vibrating objects b) dry cells c) transverse waves d) light.
2. Sounds may differ in a) amplitude b) pitch c) overtones d) all of these.
3. The loudness of a sound depends upon a) pitch b) tone c) energy d) quality.

4. The pitch of a sound is most closely related to a) material of the vibrating object b) number of vibrations per second c) temperature of the object d) size of the object.

5. A tuning fork produces a) a single pitch b) a combination of two pitches c) many pitches d) overtones.

6. Sounds are best transmitted by a) dense, rigid materials b) light, rigid materials c) dense, soft materials d) light, soft materials.

7. The pitch of a vibrating string depends upon a) length b) width c) tension d) all of these.

8. The speed of sound in water is a) 1,100 feet per second b) 4,800 feet per second c) 16,000 feet per second d) none of these.

9. Sounds travel as a) particles b) pulses c) transverse waves d) longitudinal waves.

10. Sound is affected by a) size b) shape c) material d) all of these.

11. A tuning fork of 256 hertz and one of 258 hertz are set in motion simultaneously. The number of beats produced per second is a) 2 b) 256 c) 258 d) 514.

12. Waves are best reflected by a) hard, irregular surfaces b) soft, irregular surfaces c) hard, smooth surfaces d) soft, smooth surfaces.

13. Light and sound are a) the same b) forms of energy c) transverse waves d) longitudinal waves.

14. The polaroid discs show that light a) requires a medium b) can be reflected c) can be refracted d) travels in waves.

15. The darkest part of a shadow is the a) penumbra b) umbra c) fringe d) bright zone.

16. In the reflection of light, if the angle of incidence is 30°, the angle of reflection is a) 15° b) 30° c) 60° d) 75°.

17. A plane mirror produces a) magnified images b) reduced images c) diffuse reflection d) regular reflection.

18. The bending of light is called a) refraction b) remission c) transmission d) polarization.

19. When light passes from air into water, it is a) not bent b) bent toward the normal c) bent away from the normal d) increased in intensity.

20. A convex lens a) magnifies an image b) has no focus c) has no principle axis d) is thicker at the ends than in the middle.

21. White light is composed of a) various shades of grey b) the seven colors of the visible spectrum c) a combination of red and violet d) none of these.

22. The color of an opaque object depends upon a) its density b) the color it reflects c) the color it transmits d) the color it refracts.

23. Sunburn is caused by a) radio waves b) infrared light c) visible light d) ultraviolet light.

24. A photoelectric cell changes light into a) sound b) mechanical energy c) electricity d) longitudinal waves.

25. Light waves are a) longitudinal b) transverse c) both of these d) none of these.

Matching

26. hertz
27. refraction
28. 186,000 feet/second
29. normal
30. sonar
31. vacuum
32. reflection
33. overtones
34. ultraviolet
35. light

a) perpendicular to reflecting surface
b) sound cannot pass through
c) cannot pass through ozone layer
d) angle of reflection
e) bending of light
f) quality of sound
g) transverse wave
h) vibrations per second
i) underwater sound detection
j) angle of incidence equals angle of reflection
k) density
l) speed of light

Fill in

36. Sound and light are forms of ________________.

37. Sound cannot be transmitted through a ________________.

38. Sound travels 1,100 feet per second in ________________.

39. By increasing the ______________ of a string, you increase its rate of vibration.

40. White light can be separated using a ______________.

41. Materials through which light cannot pass are ______________.

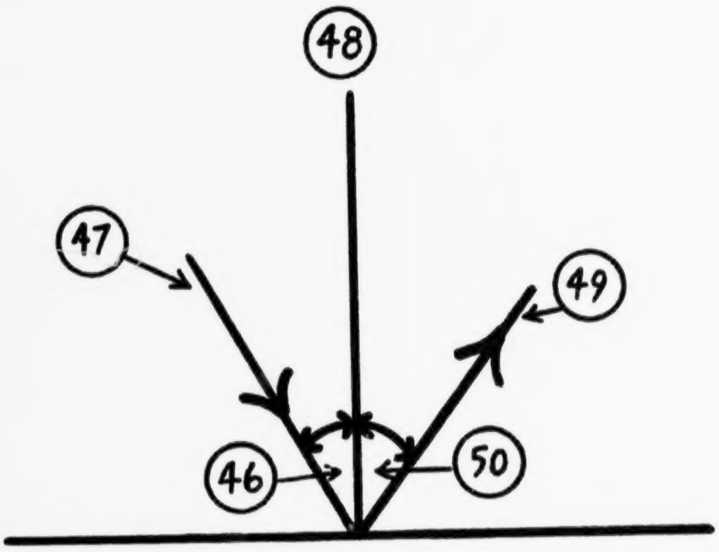
42. Light travels in ______________ lines.

43. Light entering a medium perpendicular to the surface is not ______________.

44. Green glass transmits only ______________ light.

45. Heating is caused by ______________.

Label 46, 47, 48, 49, 50 on the illustration.



SUGGESTED REFERENCES: PHYSICS

For the Teacher

BOYLAN, P. J. *Elements of Physics.* Boston: Allyn & Bacon, 1962.

BRINCKERHOFF, R. F., and others. *Exploring Physics.* New York: Harcourt, Brace and World, 1959.

CONSTANT, F. W. *Fundamental Laws of Physics.* Reading, Mass.: Addison Wesley, 1963.

DULL, C. E., and others. *Modern Physics.* New York: Holt, Rinehart & Winston, 1964.

JOSEPH, ALEXANDER, and others. *A Sourcebook for the Physical Sciences.* New York: Harcourt, Brace and World, 1961.

SEARS, F. W. *Optics,* 3d ed. Reading, Mass.: Addison Wesley, 1958.

SEARS, F. W. *Mechanics, Wave Motion and Heat.* Reading, Mass.: Addison Wesley, 1964.

For the Pupil

BARR, GEORGE. *Research Ideas for Young Scientists.* New York: McGraw-Hill, 1959.

BRINCKERHOFF, R. F., and others. *The Physical World.* New York: Harcourt, Brace and World, 1958.

NAVARRA, J. G. and GARONE, J. E. *The Physical Sciences.* New York: Harper and Row, 1967.

Physical Science Study Committee. *The Physical Sciences,* 2d ed. New York: Heath, 1966.

Unit II

CHEMISTRY

Metals

Formulas

Reactions of Metals

Activity of Metals

METALS

Suggested Lessons and Procedures

1. WHY ARE ELEMENTS ARRANGED IN GROUPS?

Outcomes

- Elements are grouped as *metals* and *nonmetals.*
- Metals are grouped to the left of the Periodic Table and nonmetals to the right.
- A column of elements on the Periodic Table is called a *group.*
- A group of elements having similar properties is called a *family.*
- *Elements are listed in order of ascending atomic number on the Periodic Table.*

Motivation

On the board, list some items found in the room. Include such items as children, plants, desks, chairs. Guide the pupils to arrange these items into groups of living and nonliving materials. Establish relationships among the members of each group. Explain that elements are grouped in similar fashion.

Development

1. Display or distribute copies of the Periodic Table. *Briefly* draw pupils' attention to some common elements on the chart. Review with pupils that metals appear on the left side while nonmetals appear on the right.
2. Define a Group as a column of elements on the Periodic Table. Establish that oxygen and sulfur are members of one group of non-

metals. Recall the experiment from 7th grade Chemistry, as performed by pupils, to establish that when steel wool is oxidized, it gains weight. Repeat this as a demonstration to emphasize the combination of oxygen with iron to form oxide. Write the word equation for this reaction: Iron + Oxygen ⟶ Iron Oxide.

2a. *If the teacher wishes, he may guide the pupils in balancing the equation:* $4Fe + 3O_2 \longrightarrow 2Fe_2O_3$

3. Repeat the demonstration performed in 7th grade Chemistry, combining iron and sulfur (proportions of 1 part iron to 2 parts sulfur). Show the formation of iron sulfide by demonstrating the loss of magnetic properties. Write the word equation:
   Iron + Sulfur ⟶ Iron Sulfide.

3a. $Fe + S \longrightarrow FeS$

4. Lead pupils to conclude that oxygen and sulfur are nonmetals which react similarly with iron, thus exhibiting similar properties.

5. Define the term, *family,* as a group of elements which have similar properties.

6. *Review the concepts of atomic numbers and atomic weight. Recall that in the days of Mendeleev the existence of many undiscovered elements was predicted from the original Periodic Table.*

Summary

1. Elements are listed in a specific order on the Periodic Table.

2. Elements are grouped as metals and nonmetals with the metals to the left and nonmetals to the right of the table.

3. A column of elements is called a Group. Oxygen and sulfur are nonmetals in the same Group because they have similar properties.

4. A *family* is a *group* of elements with similar properties.

5. *Elements are listed on the Periodic Table in order of their atomic numbers.*

Homework

1. Polish three sterling, or silverplated, teaspoons. Dip one into the yolk of an egg. Leave the second exposed to air. Wrap the third

tightly in plastic wrap as a control. Examine the three spoons the following day.

a. What color is the spoon left in the open?

b. The silver on this spoon combined with the ________ in the air.

c. What color is the spoon placed in egg yolk?

d. Egg yolk contains sulfur. The silver on the spoon placed in the egg combined with the ________.

2. *Refer to the Periodic Table and complete the chart.*

GROUP VII: A FAMILY OF ELEMENTS			
Symbol	Name	Atomic Number	Atomic Weight
F			
Cl			
Br			
I			

Materials

Periodic Table
Magnet
Filter paper
Iron filings
Sulfur powder
Test tube and holder
Bunsen burner
Steel wool
Tongs

2. WHAT MAKES A FAMILY OF METALS?

LABORATORY LESSON

Outcomes

- Metals having similar properties belong to the same family.
- Magnesium and zinc have many similar reactions and appear to be, therefore, in the same family.
- *It is possible to predict how members of a family react if we know how one of the members reacts.*

Development

NOTE: At this introductory level, we will not distinguish between the A and B designation as seen in the Periodic Table.

1. Distribute the Laboratory Worksheets and equipment to groups of pupils.
2. Guide the pupils in performing the experiment as outlined on the laboratory sheet.
3. Caution the pupils to avoid getting acid on themselves or their clothing. Instruct them to wash immediately if exposed to the acid.
4. Challenge pupils to identify the gas as hydrogen. If time permits, the teacher may demonstrate the test for hydrogen.

Summary

Guide the pupils to understand that metals having the same properties belong to the same family.

Materials

Four test tubes
Test tube rack
Water

Dilute hydrochloric acid (4:1)
Two pieces of magnesium ribbon
Two small strips of zinc

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 2

Problem: Why are magnesium and zinc in the same family?

Materials

Four test tubes
Test tube rack
Water

Dilute hydrochloric acid (4:1)
Two pieces of magnesium ribbon
Two small strips of zinc

Procedures and Observations

1. Fill 2 of the test tubes with 1 inch of water.
2. Place a strip of magnesium into one of the test tubes and a piece of zinc into the other.

   a. What happens to the magnesium in the water?

   ____

   b. What happens to the zinc in the water?

   ____

3. Gently slide a piece of magnesium into one empty test tube and a piece of zinc into the other empty test tube.

4. Add 1 inch of dilute hydrochloric acid to each of these two test tubes.

   a. What happens to the magnesium in the acid?

   ____

   b. What happens to the zinc in the acid?

   ____

   c. What else do you observe happening in both test tubes?

   ____

Conclusions

1. Magnesium and zinc are examples of (metals, nonmetals) ____________.
2. Magnesium and zinc (react, do not react) ____________ with water.
3. Magnesium and zinc (react, do not react) ____________ with acid.
4. Magnesium and zinc have similar ____________ and are, therefore, in the same ____________.
5. The bubbles produced in the test tubes with the acid indicate the presence of the gas ____________.

Homework

1. Which properties of copper make it useful in electric circuits?
2. Why is aluminum used for making pots and pans?
3. Why is mercury used in thermometers?
4. Cadmium is in the same family as magnesium.
   a. Cadmium (will, will not) ____________ react with water.
   b. Cadmium (will, will not) ____________ react in acid.
5. *Refer to the Periodic Table of Elements and complete the chart following:*

GROUP I: A FAMILY OF ELEMENTS				
Period No.	Symbol	Name	Atomic Number	Atomic Weight
1	H			
2	Li			
3	Na			
4	K			

3. WHY DO METALS OF ANY ONE FAMILY ACT ALIKE?

Outcomes

- Metals of the same family have the same number of electrons in the outermost shell of their atoms.
- All Group I metals have one electron in their outermost shell.
- Similarly, all Group II metals have two electrons, and Group III have three electrons in their outermost shells.
- *The number of electrons in the outermost shell determines the combining properties of the family.*

Motivation

Display a number of keys having two distinct patterns. Ask pupils to select the group or family of keys they would choose to try to open the lock of the classroom door. Elicit that the keys selected appear to be similar. Point out that elements too are grouped because of the similarity of their structure and activity.

Development

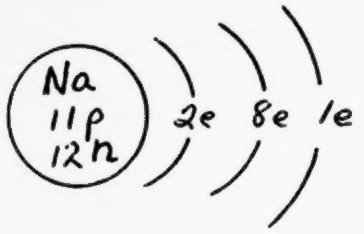
1. Using tweezers or other suitable devices, drop a ⅛" pellet of sodium into a liter beaker ⅓ filled with water. Identify sodium as a metal from Group I. Guide the pupils to observe that sodium reacts violently with water.

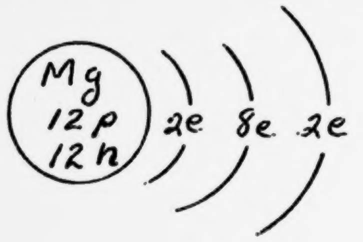
   a. Challenge pupils to identify the gas being evolved as hydrogen.

2. Recall from Lesson 2 that magnesium and zinc did not appear to react with water. These elements are metals in Group II.

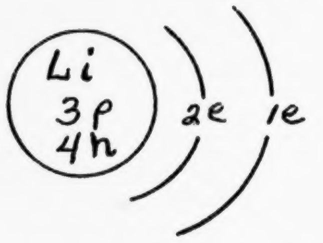
3. By means of a chalkboard diagram or a suitable atomic model with variable units, construct a model of the sodium atom. Establish that there is only one electron in the outermost shell.

4. Do the same for magnesium.





5. Draw a diagram of the lithium atom and ask the students to identify the group to which it belongs. Why?



6. Lead the pupils to understand that all elements in Group I have one electron in the outermost shell, Group II have two electrons, and Group III have three electrons.

7. *Sodium, which has one electron in its outermost shell, combined with water, whereas magnesium and zinc, which have two electrons in the outermost shell, do not. Point out that the metals of Group I react more vigorously with water than those of Group II metals. Guide the pupils to conclude that the combining properties of elements are determined by the patterns of their electron structures.*

8. *Another confirmation of the difference between Group I and Group II may be seen in the way they combine with oxygen. Group I metals will form the oxides quickly when exposed to air; Group II metals may be identified easily by their metallic appearance for some time before becoming coated with the oxide.*

Summary

1. Group I metals do not react the same as Group II metals.

2. Group I metals have only one electron in the outermost shell, Group II have two, and Group III have three.

3. *The number of electrons in the outermost shell determines combining properties.*

Homework

1. Draw atom diagrams for

Li	3p	4n	3e
Be	4p	5n	4e
B	5p	6n	5e

2. *Name 3 elements which will combine with sodium (Na). Which Group are these elements in?*

Materials

Classroom keys
Atomic model
Tweezers
Liter beaker (⅓ full of water)
Sodium (pea-sized piece)
Magnesium

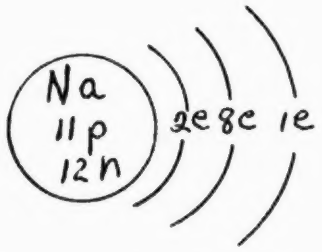
4. WHAT IS VALENCE?

Outcomes

- Metallic elements lend or transfer electrons.
- Nonmetallic elements borrow or receive electrons.
- The valence number of an element represents the number of electrons an atom will lend or borrow.

Motivation

Diagram a sodium atom on the chalkboard.



Refer to 7th grade Chemistry and point out that the outer shell would like to be complete with eight electrons (Octet Rule). Ask, "Would it be easier for sodium to gain 7 electrons or lose 1 electron to complete its outer shell?"

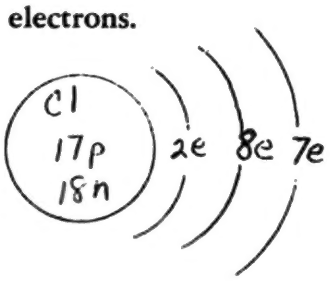
Development

1. Elicit that it would be easier for the sodium atom to lend one electron than to borrow seven electrons.

2. Establish that all metals lend electrons in order to complete the outer shell. (Draw diagrams to demonstrate.)

   Group I elements lend 1 electron.
   Group II elements lend 2 electrons.
   Group III elements lend 3 electrons.

3. Draw the chlorine atom:



   Would it be easier for chlorine to lend 7 electrons or borrow 1 electron to complete its outer shell? Elicit that it is easier to borrow one electron than to lend seven.

4. Establish that all nonmetals borrow electrons in order to complete the outer shell. (Draw diagrams to demonstrate.)

   Group V borrows 3 electrons
   Group VI borrows 2 electrons
   Group VII borrows 1 electron

5. Define *valence* as the tendency to lend or borrow electrons. Lenders have a positive (+) valence and borrowers have a negative (−) valence. The *valence number* tells how many electrons are loaned or borrowed.

6. Generalize that atoms with fewer than 4 electrons in the outer shell behave as metals (they lend electrons). Atoms with more than 4 electrons in the outer shell behave as nonmetals (they borrow electrons).

7. *Do elements in Group IV lend or borrow electrons? Guide the pupils to realize that atoms with 4 electrons in the outer shell can either lend 4 electrons or borrow 4 electrons. Therefore, these elements can behave as either metals or nonmetals. These elements are called amphoteric. (Examples: carbon, tin, lead.)*

8. *Will elements in Group VIII (or Group 0) lend or borrow electrons? Identify the inert gases as elements with complete outer shells.*

Summary

1. Metal atoms are in Groups ________, ________, and ________.
2. Metal atoms have fewer than ________ electrons in the outer shell.
3. Nonmetal atoms are in Groups ________, ________, and ________.
4. Nonmetal atoms have more than ________ electrons in the outer shell.
5. An atom with a positive (+) valence is a ________ (metal, nonmetal), while an atom with a negative (−) valence is a ________.
6. An atom with valence number −3 will (lend, borrow) ________ electrons.
7. *An amphoteric element will either ________ or ________ electrons.*
8. *The inert gases are complete with ________ electrons in the outer shell.*

Homework

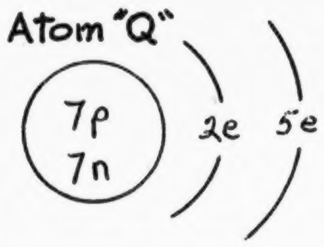
1. Use the Periodic Table to list all elements from Atomic Number 1 to 20. Next to each atom write the valence number.
2. Draw the electron diagrams for the beryllium atom and the oxygen atom.
3. *Draw a diagram of the carbon atom. Explain its valence.*
4. *Draw a diagram of the neon atom. What is its valence?*

Materials

Periodic Table of Elements
Molecular models
Charts of atomic structure

REVIEW AND REINFORCEMENT (1-4)

Completion



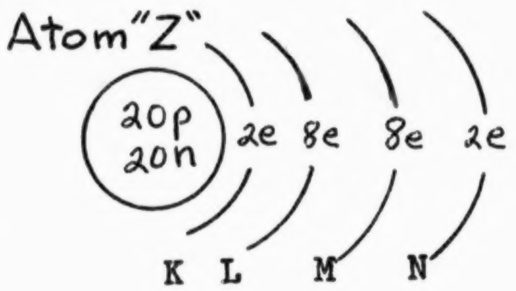
1. The atomic number of this atom is ______.

2. Atom "Q" would be a ____________ (metal, nonmetal).

3. This atom would probably (borrow, lend) ____________ electrons.

4. Atom "Q" is (more, less) ____________ active than an atom with seven electrons in its outermost shell.

5. An atom with the atomic number 15 (would, would not) ____________ be a member of the same family as atom "Q".



6. Atom "Z" is a ____________ (metal, nonmetal.)

7. Atom "Z" tends to ________ (lend, borrow) electrons.

8. The valence number of atom "Z" is ____________.

9. Atom "Z" is ____________ (more, less) active than an atom found in Group III.

10. The "K" shell of an atom is filled when it contains (1,2,4,7,8) ____________ electrons.

Suggested Films

The Strange Case of the Cosmic Rays, Bell Telephone Co.

"A" Is for Atom, Atomic Energy Commission

Our Friend the Atom, Disney Films

NOTE: These films may be ordered directly from sources listed, free of charge.

Matching

1. Metal
2. Family
3. Group
4. Compound
5. Electrons
6. Nonmetal
7. Valence

A. Negative particles found in an atom
B. Positive particles found in an atom
C. An atom which borrows electrons
D. An element with 8 electrons in the outer shell
E. The number of electrons exchanged
F. Elements with similar properties are found in a
G. Elements having the same number of electrons in the outer shell
H. A substance formed when elements exchange electrons
I. An atom which lends electrons

◆

5. HOW IS VALENCE USED TO FIND THE CORRECT FORMULA FOR A COMPOUND?

Outcomes

- The molecular formula represents the number of atoms of each element in the compound.
- The formula of a compound is determined by the number of electrons a metal atom can lend and by the number of electrons a nonmetal atom can borrow.

Motivation

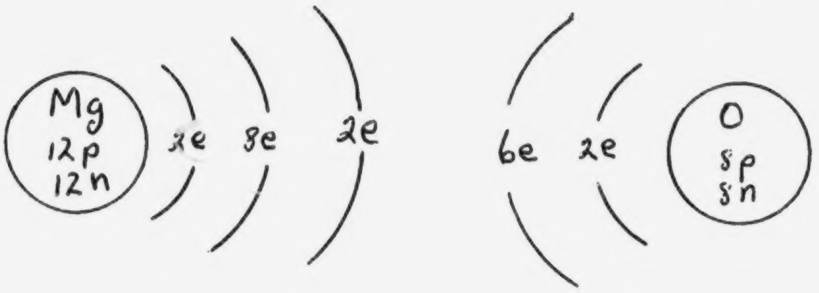
Ignite a piece of magnesium ribbon. (Caution students not to look directly at the bright light.) Show the class the white powder that forms and identify it as magnesium oxide. Write the word equation for the reaction on the board.

$$\text{Magnesium} + \text{Oxygen} \longrightarrow \text{Magnesium Oxide}$$

Lead the class to conclude that the metal magnesium combined with the nonmetal oxygen. Ask the class, "What happened when the atoms of magnesium and oxygen combined?"

Development

1. Draw atom diagrams on the board as shown:



2. Guide the pupils to realize that magnesium can lend its two outer electrons to oxygen, thereby completing the outer shells of both. Draw arrows to show the sharing of two electrons by the outer shells of both.

3. Since one atom of magnesium satisfied one atom of oxygen by the transfer of two electrons, the formula for the compound *magnesium oxide* must be MgO.

4. Elicit the valence numbers as +2 for magnesium and −2 for oxygen. Develop the concept that the simple addition of valence numbers in a compound totals zero. Use several compounds to illustrate.

5. *Gaseous hydrogen exists as a diatomic molecule (2 atoms, e.g.* H_2*). Explain this as the sharing of electrons to satisfy the outer shells.*

6. *Ask the class, "Can elements from Group 0 form compounds?" Establish that these elements have a valence number of zero and do not lend or borrow electrons under normal conditions.*

Summary

1. Atoms combine with one another to form compounds in order to complete their outer shells.

2. The formula tells us the number of atoms of each element in the compound.

3. The valence numbers of atoms determine formulas of compounds. The sum of the valence numbers in a compound equals zero.

Homework

Complete the tables by writing the formula of the compounds formed by the following elements.

	F-	Cl-	Br-	I-
H+				
Na+		Na Cl		
K+				

	O^{--}	S^{--}
Ba++		
Ca++		CaS
Mg++		

	N^{---}	P^{---}
Al+++		

Materials

3″ to 4″ of magnesium ribbon	Tongs or forceps

6. WHY IS THE FORMULA OF CARBON DIOXIDE CO_2?

Outcomes

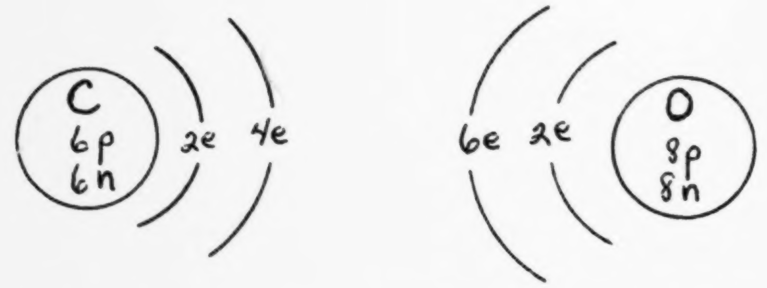
- When compounds form, all of the outer electrons must be accounted for.
- A two element compound sometimes requires more than one atom of the combining elements.
- *A compound may consist of more than two elements.*

Motivation

Pass some carbon dioxide into limewater. Recall the cloudy precipitate as a test for the gas. Ask the class to identify the gas and write its formula on the board. Ask why the formula is CO_2

Development

1. Draw diagrams of carbon and oxygen atoms as shown:



What is the valence number of carbon? Of oxygen? Ask, "Will one atom of oxygen satisfy one atom of carbon?" Lead the class to conclude that:

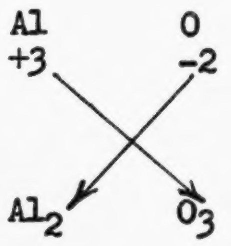
a. One atom of oxygen will accept *only* two electrons from the carbon atom.

b. The sum of the valence numbers does not total zero: e.g., $+4 - 2 = +2$

2. Point out that one more atom of oxygen is needed. Draw another oxygen diagram on the board and use arrows to show the electron transfer. Sum up the valence numbers: $+4 - 2 - 2 = 0$

NOTE: One atom of carbon sometimes unites with one atom of oxygen to form the compound, carbon monoxide. This is an unstable compound which soon unites with oxygen to form carbon dioxide.

3. Practice: Find the formula for aluminum oxide.



a. Write the valence number of the metal atom under the name of the metal. (+3)

b. Do the same for the nonmetal. (−2)

c. Crisscross the valence numbers.

d. Write the formula.

4. Discuss the formation of this compound in terms of electron transfer. Two aluminum atoms are required to lend a total of six electrons to three atoms of oxygen.

5. *Sodium hydroxide (NaOH) is a compound made of three elements. Explain its existence by totalling the valence numbers:* (Na O H) ($+1 - 2 + 1 = 0$)

Point out that the oxygen atom shares its electrons with two different elements: Na and H.

Summary

1. The oxygen atom needs __________ electrons to complete its outer shell.

2. The carbon atom can lend __________ electrons.

3. The carbon atom requires __________ atoms of oxygen to account for all its electrons.

4. The equation for the formation of carbon dioxide is:

$$C + O_2 \longrightarrow CO_2$$

   a. The valence number for carbon is __________.

   b. The valence number for oxygen is __________.

   c. The sum of the valence numbers in the compound CO_2 is __________.

5. a. The valence number of aluminum is __________.

   b. The valence number of oxygen is __________.

   c. The formula for the compound aluminum oxide is __________.

6. *An atom may share its electrons with (only one) (more than one) __________ element(s).*

Homework

Use the concept of valence numbers to write the formula for the compounds.

	F^-	Cl^-	Br^-	I^-	$O^=$	$S^=$	$N^{\equiv}$	$P^=$
H^+	HF							
Na^+								
K^+								
Ca^{++}								
Mg^{++}								
Al^{+++}								

Materials

CO_2	Limewater

7. WHAT HAPPENS TO ELECTRONS DURING A CHEMICAL CHANGE?

LABORATORY LESSON

Outcomes

- Metal atoms react with acids and bases to lose electrons. When a metal atom loses electrons, it becomes a positively charged ion (+).
- The electrons released by the metal as it reacts with the acid or base can produce an electric current.

Development

1. Distribute materials used to make a dry cell.
2. Briefly review the terms "electrode" and "electrolyte" (7th grade Chemistry). Identify the zinc strip and carbon rod as the electrodes and the ammonium chloride as the electrolyte.

Summary

Refer to questions on the Worksheet to reinforce concepts. Stress the idea that when a metal atom loses electrons it becomes a positively charged ion (8th grade Chemistry). The electrons, released by the metal, produce a flow of electricity.

Materials

Beaker, 50 ml
Ammonium chloride
Powdered carbon
Zinc strips
Switch
Carbon rods (3-4" long)
Powdered manganese dioxide
Light bulb in socket (or galvanometer)
Wood splints
Wire connectors

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 7

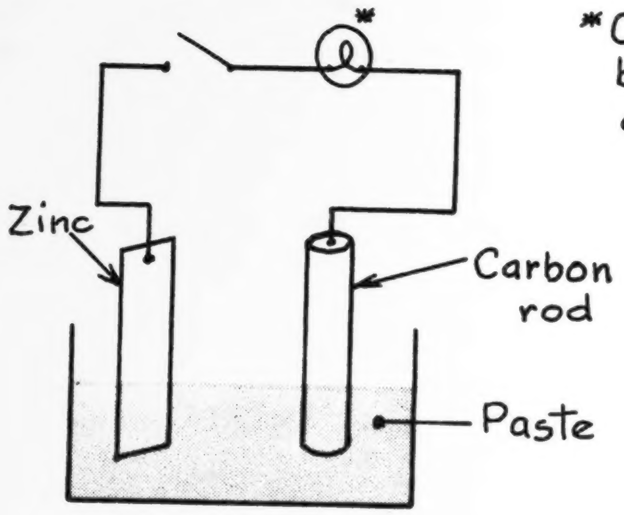
Problem: What happens to electrons during a chemical change?

Materials

- Beaker, 50 ml
- Ammonium chloride
- Powdered carbon
- Zinc strips
- Switch
- Carbon rod
- Powdered manganese dioxide
- Light bulb in socket (or galvanometer)
- Wood splint
- Wire connectors

Procedure and Observations

1. Fill the beaker with ½ inch of ammonium chloride and add another ½ inch of powdered manganese dioxide.
2. Add enough carbon powder to fill the container up to ¾ of its capacity.
3. Add just enough water to make a wet paste of the mixture in the container. Mix the paste with a wood splint.
4. Attach the wires to form the circuit and place the zinc strip and the carbon rod into the paste as shown in the diagram:



*Galvanometer may be used in place of light bulb

CAUTION: Be sure the metal strip and the carbon rod do not touch.

5. Close the circuit for just a second. What happens while the switch is closed?
6. Repeat step 5. Does the same thing happen?

Summary

1. When the switch is closed, ____________ is produced.
2. Electricity is the flow of ____________ in a closed circuit.
3. The zinc atom (gains, loses) ____________ electrons to become a positively charged ion.

4. The light goes on (or the galvanometer needle moves) because ____________ are moving through it.

5. Indicate the direction of the flow of electrons by drawing arrows on the diagram.

6. In a chemical change ____________ move from one atom to another.

7. *Complete the equations:*

$$\underset{\text{(metal)}}{Zn^{\circ}} \longrightarrow \underset{\text{(ion)}}{Zn^{++}} + \_\_\_\_\_\_\_\_$$

$$\underset{\text{(metal)}}{C^{\circ}} + 2e^{-} \longrightarrow \underset{\text{(ion)}}{\_\_\_\_\_\_\_\_}$$

$$NH_4Cl \longrightarrow \underset{\text{(ion)}}{\_\_\_\_\_\_\_\_} + \underset{\text{(ion)}}{Cl^{-}}$$

Homework

1. Examine a flashlight battery.
   a. The case of the battery is made of ____________.
   b. The middle terminal of the battery is connected to a ____________ rod.
   c. The electrons flow through the wire from the ____________ to the ____________.
2. *a. Why is it possible to use copper in place of carbon in a battery?*
   b. Write the equations to show the electron transfers for the zinc and copper in the wet cell, using HCl in place of NH_4Cl.

8. WHY DO SOME METALS FORM MORE THAN ONE COMPOUND WITH THE SAME NONMETAL?

Outcomes

- Some metals, like *iron, tin, copper,* and *mercury,* form more than one compound with the same nonmetal.
- These metals have more than one valence.
- *The name given to the metal compound indicates the valence of the metal.*
- *The existence of polyvalent elements proves that these metals exhibit more than one electron configuration.*

Motivation

Exhibit large stock bottles of ferrous chloride and ferric chloride. Elicit that they differ in color. Have a pupil read the labels and write the formulas and names on the board.

$FeCl_2$ — ferrous chloride $FeCl_3$ — ferric chloride

Establish that these are two distinctly different compounds made of iron and chlorine. Pose the question, "Why is it possible for iron to combine with chlorine in two different ways?"

Development

1. Refer to the Periodic Table to establish that iron has two electrons in its outer shell. Under normal conditions we would expect the iron atom to combine with two atoms of chlorine to form $FeCl_2$ (ferrous chloride).

2. The existence of $FeCl_3$ (ferric chloride) demonstrates that, at times, the iron atom acts as though it had three electrons in its outer shell.

3. In $FeCl_2$ iron has a valence of +2. In $FeCl_3$ iron has a valence of +3. Metal atoms which have more than one valence can form more than one compound with the same nonmetal. Such atoms are called *polyvalent* atoms.

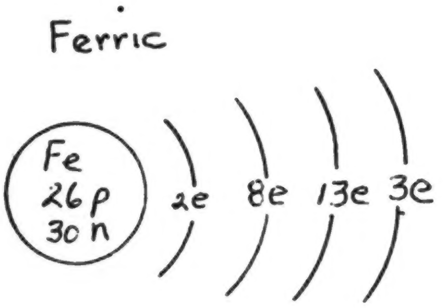
4. Help the pupils to develop the table on the chalkboard.

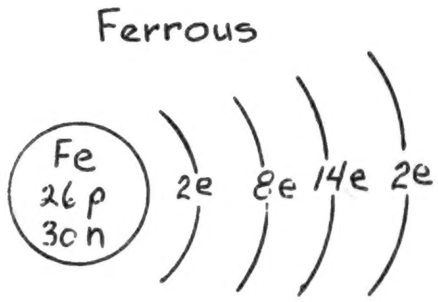
SOME POLYVALENT METALS				
METAL	LOWER VALENCE		HIGHER VALENCE	
Iron	Fe^{++}	$Fe\ Cl_2$	Fe^{+++}	$Fe\ Cl_3$
Copper	Cu^{+}	$Cu\ Cl$	Cu^{++}	$Cu\ Cl_2$
Mercury	Hg^{+}	$Hg\ Cl$	Hg^{++}	$Hg\ Cl_2$
Tin	Sn^{++}	$Sn\ Cl_2$	Sn^{+++}	$Sn\ Cl_4$

5. *The suffix "ous" indicates the lower valence number:*
   $FeCl_2$ — *ferrous chloride* $CuCl$ — *cuprous chloride*

6. *The suffix "ic" indicates the higher valence number:*
   $FeCl_3$ — *ferric chloride* $CuCl_2$ — *cupric chloride*

7. *Draw the atom diagrams to demonstrate the electron configurations of the two valences of iron. (See next page.)*





Note: *The third shell of electrons is incomplete. Therefore, chemists believe that one electron from this shell can move into the outer shell.*

Summary

1. What is the valence of iron in $FeCl_2$?
2. What is the valence of iron in $FeCl_3$?
3. Atoms with more than one valence are called __________ atoms.
4. Some of the other metals which have more than one valence are __________ and __________.
5. *The suffix ________ is used to indicate the lower valence.*
6. *The suffix _______ is used to name the higher valence compound.*
7. *Polyvalent elements exhibit (one, more than one) __________ possible electron configuration.*

Homework

1. Complete the chart by inserting the appropriate formula for each compound.

NONMETAL	Fe^{++}	Fe^{+++}	Ni^{++}	Ni^{+++}	Hg^{+}	Hg^{++}
Cl^{-}	$FeCl_2$					
O^{--}		Fe_2O_3				

2. *Name each compound on the chart.*

Materials

Stock bottles containing ferrous chloride and ferric chloride
Periodic Table

FORMULAS

Suggested Lessons and Procedures

9. WHAT IS A "RADICAL"?

- Certain groups of atoms behave like a single atom during a chemical change.
- Such groups of atoms are called *radicals.*
- A *radical* has a particular valence number.
- *Compounds containing radicals dissociate to form ions.*
- *Radicals have complete electron structures.*

Motivation

Display stock bottles of sodium hydroxide, sodium sulfate, ammonium hydroxide, and calcium carbonate. Have pupils check the formulas on the labels and write each on the board. Elicit that the words hydroxide, sulfate, ammonium, and carbonate are names of more than one element. Ask, "Why do we group these elements together?"

Development

1. On the board, write the symbols for the atom groups as shown:

NAME	FORMULA	ATOM GROUP
sodium hydroxide	$NaOH$	OH
sodium sulfate	Na_2SO_4	SO_4
calcium carbonate	$CaCO_3$	CO_3
ammonium hydroxide	NH_4OH	NH_4, OH

2. Consider the formula $CaCO_3$. Ask, "What is the valence of the calcium atom?" Recall that the sum of the valence numbers in a compound equals zero. Since the calcium atom has a valence of +2, the carbonate group (CO_3) must have a valence of −2.

3. Explain that the carbonate group acts like a single atom. Such a group of atoms is called a radical.

4. Refer to the chart on the board and identify the valence number of each radical.

   NOTE: Ammonium hydroxide contains two radical NH_4, valence number +1 and OH, valence number −1.

5. List some additional radical compounds on the board and determine the valence number of the radical from the formula. Stress that the valence of the radical must equal the valence of the metal.

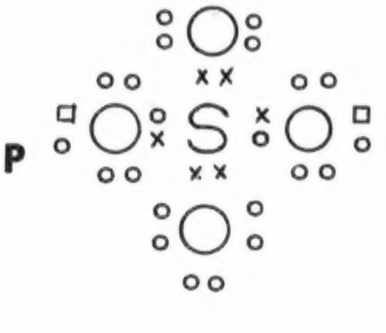
Name of Compound	Formula	Radical	Valence Number
Sodium nitrate	$NaNO_3$	NO_3	−1
Potassium chlorate	$KClO_3$	ClO_3	−1
Potassium permanganate	$KMnO_4$	MnO_4	−1
Sulfuric acid	H_2SO_4	SO_4	−2
Aluminum phosphate	$AlPO_4$	PO_4	−3
Sodium carbonate	Na_2CO_3	CO_3	−2
Ammonium chloride	NH_4Cl	NH_4	+1

6. *Recall from 8th grade Chemistry that, in solution, electrolytes dissociate to form ions. For example:*

$$NaOH \longrightarrow Na^+ + OH^-$$
$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{--}$$

The radicals here behave like a single charged atom or ion.

7. *The sum of the valence numbers of the atoms within a given rad-*



○ — *oxygen electrons*
x — *sulfur electrons*
□ — *2 electrons from combining element (example: 2 hydrogen atoms)*

ical does not always equal the valence number assigned to the radical. For example, the valence number for SO_4 is -2. However, the valence of sulfur is -2 and the valence of oxygen is also -2. Thus we might assume that the valence of SO_4 should be -10. Draw the atom diagram for SO_4 to show the sharing of electrons between the sulfur atom and the oxygen atom to help explain the valence number.

Summary

1. A group of atoms which behaves like a single atom in a chemical change is called a radical.
2. A radical has a particular valence number.
3. *When electrolytes dissociate, the radicals behave like ions.*
4. *Radicals often complete their electron structures by the sharing of electrons within the radical.*

Homework

1. Write the formulas for the compounds indicated on the chart.

	RADICAL			
Element	OH	SO_4	CO_3	PO_4
Na				
H				
Ca				
K				
Al				

2a. Name each of the compounds in the table above.

b. Write the valence numbers for the elements and the radicals in each compound.

Materials

Stock bottles of:

Sodium hydroxide	Ammonium hydroxide
Sodium sulfate	Calcium carbonate

◆

REVIEW AND REINFORCEMENT (5-9)

The teacher may select the most suitable of the following suggested activities for review and reinforcement.

Essay

> An *atom* is composed of *protons, electrons,* and *neutrons.* In a chemical reaction, only the electrons take part. The rest of the atom does not change. *Valence* is a number which tells us how many electrons take part in a reaction. Metal atoms are lenders of electrons and have a *positive valence* while nonmetals are borrowers and have a *negative valence.* Some atoms are exceptional in that they have more than one valence number. Examples of such *polyvalent atoms* are iron, copper, nickel, cobalt, and mercury. In some instances a group of atoms will react like a single atom. These groups of atoms we call *radicals.* A radical has a particular valence number. Some examples of radicals are ammonium (NH_4), sulfate (SO_4), carbonate (CO_3), phosphate (PO_4), and nitrate (NO_3). Whenever elements react and combine with one another, a new compound is formed with its own special *formula.*

1. Write a suitable title for this selection.
2. Define each of the italicized terms.

Test: True or False

1. Indicate whether the statement is True or False. If the statement is False, rewrite the statement to make it True.
   a. An atom is composed of only protons and neutrons.
   b. Valence tells us the number of electrons an atom can borrow.
   c. A nonmetal is a lender of electrons.
   d. Zinc is a borrower of electrons.
   e. Oxygen has a negative valence.
   f. Iron, copper, and sodium are polyvalent atoms.
   g. All radicals have a negative valence

h. PO_4 is a phosphate radical.

i. Each atom in a radical acts independently.

j. A formula tells us the story of a reaction.

Activity

Use various colors of clay to make models of the atoms found in the radical OH.

◆

10. WHAT KINDS OF COMPOUNDS DO METALS MAKE?

- The compounds formed when metals combine with nonmetals include *sulfides, oxides,* and *chlorides.*
- A chemical equation may be used to describe a chemical reaction.
- *Chemical equations must be balanced.*

Motivation

Pose the question, "What happens to iron when it rusts?" Help pupils to recall that when iron rusts, it combines with oxygen to form iron oxide. Similarly, other metals combine with nonmetals to form compounds.

Development

1. Heat about 1 gram of sulfur in a pyrex test tube until it boils, and the sulfur vapors nearly fill the test tube. Insert a thin strip of copper foil into the test tube and remove from the heat. Direct the pupils to observe the exothermic reaction characterized by the glow of copper, and the formation of the black compound.
   a. The metal used in the reaction is ____________.
   b. The nonmetal it reacted with is ____________.
   c. The equation for this reaction is ____________.
   (copper + sulfur ⟶ copper sulfide)
2. Rewrite the word equation, using chemical symbols:

$$Cu + S \longrightarrow CuS$$

3. Emphasize the formation of a *sulfide* whenever a metal reacts with sulfur.

4. Recall the formation of iron oxide when steel wool was burned in air, and magnesium oxide when magnesium ribbon was burned. Write the balanced equations for these reactions on the board:

   a. $4Fe + 3O_2 \longrightarrow 2Fe_2O_3$ b. $2Mg + O_2 \longrightarrow 2MgO$

Point out that whenever a two-element compound is formed, the name of the compound ends in *ide*.

5. *Place a small amount of sulfur (size of a pinhead) on a silver or silver-plated spoon and heat. Elicit that a metallic sulfide is formed and write the equation for the reaction.* $2Ag + S \longrightarrow Ag_2S$

   Ask, "Is the equation balanced?" Develop the following method used to balance the equation:

   a. $S^\circ + 2e^- \longrightarrow S^=$ *(borrower)*

   b. $Ag^\circ - e^- \longrightarrow Ag^+$ *(lender) (Establish the need to double all parts of this equation to balance the number of electrons exchanged.)*

   c. $2Ag^\circ - 2e^- \longrightarrow 2Ag^+$ *(Conclude that the formula for silver sulfide must be* Ag_2S*)*

Summary

1. Metals combine with __________ __________ to form a compound.

2. Metals and oxygen unite to form compounds called __________.

3. Metals + sulfur ⟶ __________.

4. Metals + chlorine ⟶ __________.

5. All compounds which are made of two elements end in the suffix __________.

6. The story of a chemical reaction is written in the form of an __________.

7. *In order to balance an equation, we must determine the number of electrons gained. The electrons gained must equal the number of electrons lost.*

Homework

Complete the chart:

METAL AND VALENCE	NONMETAL AND VALENCE	COMPOUND FORMULA	NAME OF COMPOUND
Mg +2	O −2	MgO	Magnesium Oxide
Fe +2	O −2		
Fe +3	O −2		
Ag +1	O −2		
Mg +2	Cl −1		
Fe +2	S −2		

Balance the equation by the electron method: $Fe + Cl_2 \longrightarrow FeCl_3$

Materials

Asbestos pad	Thin strip copper foil
Tongs	Test tube and holder
1 gm sulfur	Silver or silver-plated teaspoon
Pinch of sulfur	

11. WHAT IS A FORMULA WEIGHT?

Outcomes

- The *formula weight* is the sum of all the atomic weights of all the atoms in a compound.
- The *subscript* which follows the atom symbol indicates the number of atoms of that element.
- *Formulas can be used to calculate the* percent composition *by weight of elements in a compound.*

Motivation

Suppose we went to the store and purchased one pound of sugar, five pounds of potatoes, and two pounds of onions. The clerk packed all of these in one bag. How much would this bag weigh?

Development

1. Lead the pupils to understand that like the mixture of items in the bag, the total weight of a compound is also determined by the weight of the separate elements that go into it. The total weight of a compound is its *formula weight.*
2. In order to calculate the formula weight of a compound:
   a. Write the correct formula for the compound, e.g., CuS
   b. Use the Periodic Table to find the atomic weight of each element, e.g., Cu = 64
      S = 32
   c. Total the atomic weights of all atoms in the compound, e.g., 64 + 32 = 96. The formula weight of CuS is 96.
3. Calculate the formula weight for potassium chlorate.
   a. The correct formula is $KClO_3$.
   b. The atomic weights are: K = 39 Cl = 35 O = 16

      Call attention to the subscript 3 after the symbol O. Elicit that this means there are three atoms of oxygen in this compound. The atomic weight of oxygen must, therefore, be multiplied by three.
   c. The formula weight for $KClO_3$ is therefore:
      39 + 35 + 48 = 122
4. Use several compounds such as: H_2SO_4, Na_2CO_3, NaOH to practice finding the formula weight of a compound.
5. *Pose the problem: A chemist wants to prepare sulfur dioxide (SO_2). What percentage of sulfur is present in sulfur dioxide?*

Element	*Number of atoms*	×	*Atomic weight*	=	*Total weight of the element*
S	*1*		*32*		*32*
O	*2*		*16*		*32*
				Formula weight =	*64*

$$\frac{\textit{Total weight of element}}{\textit{Total weight of compound}} \times 100 = \%\ \textit{weight of element}$$

$$\%\ S = \frac{32}{64} \times 100 = 50\%$$

For practice calculate the percentage of oxygen in potassium chlorate ($KClO_3$*).*

Summary

1. In order to calculate the formula weight of a compound:
   a. Write the correct formula.
   b. Find the atomic weight of each element in the formula.
   c. Multiply the atomic weight by the subscript. (Where there is no subscript, the number "1" is understood.)
   d. Total the atomic weights to get the formula weight of the compound.
2. *To find the percentage composition of an element in a compound, divide the total weight of the element by the total weight of the compound and multiply by 100.*

Homework

1. Use the Periodic Table to find the formula weight of each:

   NH_4Cl, $C_{12}H_{22}O_{11}$, $(NH_4)_2\ CO_3$

2. *Find the percentage of hydrogen in* $(NH_4)_2\ CO_3$.

Materials

Periodic Table

REACTIONS OF METALS

Suggested Lessons and Procedures

12. CAN MATTER BE CREATED OR DESTROYED?

LABORATORY LESSON

Outcomes

- In a chemical reaction, the total weight of the *reactants* (starting substances) is equal to the total weight of the *products.*
- The elements which take part in the beginning of a reaction are the same elements present at the end of the reaction.
- The *Law of Conservation of Matter* states that matter can neither be created nor destroyed.

Development

1. Recall the laboratory lesson in grade 7 Chemistry where it was established that steel wool gains weight when burned. Review that the gain in weight was due to oxidation.
2. Distribute the materials and Worksheets.
3. Caution the pupils to:
   a. Leave switch open till all connections are made.
   b. Refrain from touching the flashbulb until it cools.

Summary

Refer to questions on Worksheet to reinforce concepts.

Materials

Platform balance
Unused flashbulb
Two dry cells
Switch
Wire
Asbestos pad

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 12

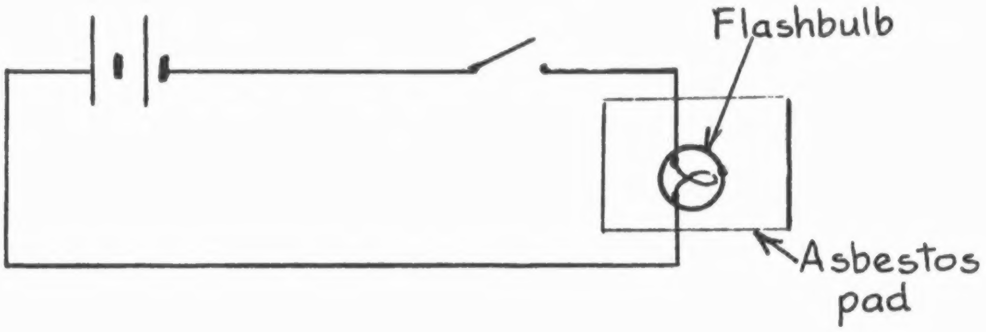
Problem: **Can we create or destroy matter?**

Materials

Platform balance
Unused flashbulb
Two dry cells
Switch
Wire
Asbestos pad

Procedures and Observations

1. Weigh the unused flashbulb and insert the weight in the table below.
2. Connect the flashbulb into the circuit as shown in the diagram.



3. Close the switch. What happens inside the flashbulb? ______________

    ____

4. Open the switch. Allow the bulb to cool, then disconnect it from the circuit, and reweigh it. Record its weight in the table:

TABLE OF OBSERVATIONS

Weight of unused flashbulb ______________________ grams
Weight of bulb after ignition ______________________ grams
Change in weight ______________________ grams

(Use "+" for a gain in weight or "—" for a loss.)

5. When the flashbulb was ignited, a ________ (chemical, physical) change took place.

6. The aluminum wire in the bulb combined with ________ (gas) in the bulb.

7. The chemical equation for this reaction is: ________ + ________ $\longrightarrow Al_2O_3$
(aluminum oxide)

8. The total weight of the bulb ________ (changed, did not change).

Conclusions

1. In a chemical reaction, the atoms of the elements which react ________ (are, are not) destroyed.

2. Matter ________ (can, cannot) change form, but it ________ (can, cannot) be destroyed or created.

3. The rule which states that matter can neither be created nor destroyed is called the ***Law of Conservation of Matter.***

Homework

1. Calculate the atomic weights of the reactants (elements), and compare them to the formula weight of the product (compound):

EQUATION	ATOMIC WEIGHTS OF REACTANTS	FORMULA WEIGHT OF PRODUCT
$2H_2 + O_2 \longrightarrow 2H_2O$	$2H_2$= O_2= Total= ________	$2H_2O$=________
$2Ag + S \longrightarrow Ag_2S$	2Ag= S= Total= ________	Ag_2S=________
$2Cu + O_2 \longrightarrow 2CuO$	2Cu= O_2= Total= ________	2CuO=

13. HOW DO WE CLASSIFY REACTIONS IN WHICH COMPOUNDS ARE FORMED AND BROKEN DOWN?

Outcomes

- A reaction in which a metal and nonmetal combine is called *synthesis.*

- A reaction in which a compound is broken down into simpler substances is called *decomposition.*
- *Unstable compounds decompose more readily than stable compounds.*
- *During a chemical reaction, energy is either released or absorbed.*

Motivation

Recall the use of the Hoffman Apparatus to break up water and the burning of hydrogen gas to form water (7th grade Chemistry).

> NOTE: If time permits, it is advisable to repeat these two demonstrations. Emphasize that in the first reaction, water is *broken down* and in the second reaction, water is *formed.*

Development

1. Have the pupils write the word and symbol equations for the two reactions:

   a. hydrogen + oxygen ⟶ water
   $2H_2 + O_2 \longrightarrow 2H_2O$

   b. water ⟶ hydrogen + oxygen
   $2H_2O \longrightarrow 2H_2 + O_2$

2. Identify reaction "a" as a *synthesis* or combination reaction in which a metal and nonmetal combine to form a compound. Identify reaction "b" as a *decomposition* reaction in which a compound is broken down into its elements.

3. Help the pupils to complete the following synthesis reactions:

   $Fe + S \longrightarrow$ $4Al + 3O_2 \longrightarrow$
   $4Fe + 3O_2 \longrightarrow$ $2Fe + 3Cl_2 \longrightarrow$

4. Guide the pupils in writing the products of these decompositions:

   $2HgO \longrightarrow$ $2KClO_3 \longrightarrow$
   $2H_2O_2 \longrightarrow$ $Al_2S_3 \longrightarrow$

5. *Stable compounds (in which electrons are tightly held) are made from active elements. Unstable compounds (in which the electrons are loosely held) are made from less active elements. Unstable compounds (example: H_2O_2) will decompose more readily than stable compounds (example: H_2O).*

6. *Review the concept of exothermic and endothermic reactions (7th grade Chemistry). Cite the decomposition of mercuric oxide to form mercury and oxygen as an endothermic reaction which requires energy. Refer to the burning of steel wool in air to form iron oxide as an exothermic reaction in which energy is given off.*

Summary

1. A reaction in which a metal and nonmetal combine is called __________.
2. A reaction in which a compound is broken down into simpler substances is called __________.
3. *Active elements combine to form __________ compounds (stable, unstable).*
4. *Inactive elements combine to form __________ compounds (stable, unstable).*
5. __________ *(stable, unstable) compounds decompose more readily.*
6. *If energy is absorbed during a chemical reaction, the reaction is* __________.
7. *If energy is released during a chemical reaction, the reaction is* __________.

Homework

For each of the following equations state whether the reaction is a synthesis or a decomposition.

a. $2Mg + O_2 \longrightarrow$

b. $2Al_2O_3 \longrightarrow$

c. $2Cu + O_2 \longrightarrow$

d. $2HBr \longrightarrow$

Materials (optional)

Hoffman apparatus

2 test tubes

Wood splints

REVIEW AND REINFORCEMENT (10-13)

Test

1. List 4 elements which form diatomic molecules.
2. How many elements does an oxide contain?
3. Write the names and formulas of 3 different oxides.
4. State the Law of Conservation of Matter.
5. Write the equation for a synthesis type of chemical reaction.
6. Complete each of the following:

   a. $H_2O_2 \longrightarrow$ __________ + __________

   b. $K + O_2 \longrightarrow$ __________

   c. $Cu +$ __________ $\longrightarrow CuS$

   d. $HgO \longrightarrow$ __________ + __________

   e. $Fe + O_2 \longrightarrow$ __________

7. For each reaction listed above, state whether synthesis or decomposition occurred.
8. Calculate the formula weight of H_2O_2,Fe_2O_3 and HgO from the *data* supplied:

   atomic weights H = 1 Hg = 201
   O = 16 Fe = 56

9. Complete the chart

REACTANT	VALENCE	REACTANT	VALENCE	FORMULA	NAME OF PRODUCT
Ag	+1	Cl	−1		
Pb	+2	Cl	−1		
				Fe_2O_3	
NH_4	+1	CO_3	−2		
	+2				mercuric sulfide

10. Briefly describe an experiment designed to prove the Law of Conservation of Matter.

11. Write a brief explanation of why a copper roof turns green in color after exposure to the atmosphere.

Suggested Books for Reports

The Search for the Elements by Asimov.
Molecules Today and Tomorrow by Hyde.
Great Discoveries by Young Chemists by Kendall.
So You Want to Be a Chemist by Nourse.

Complete data on these books will be found in the bibliography at the end of this unit.

◆

14. HOW DOES ONE ELEMENT REPLACE ANOTHER IN A COMPOUND?

Outcomes

- Metals can replace other metals in a compound.
- Hydrogen can be replaced by a metal.
- The element which is replaced is set free.
- *The more active metal gives up electrons which the less active, or replaced, metal accepts.*

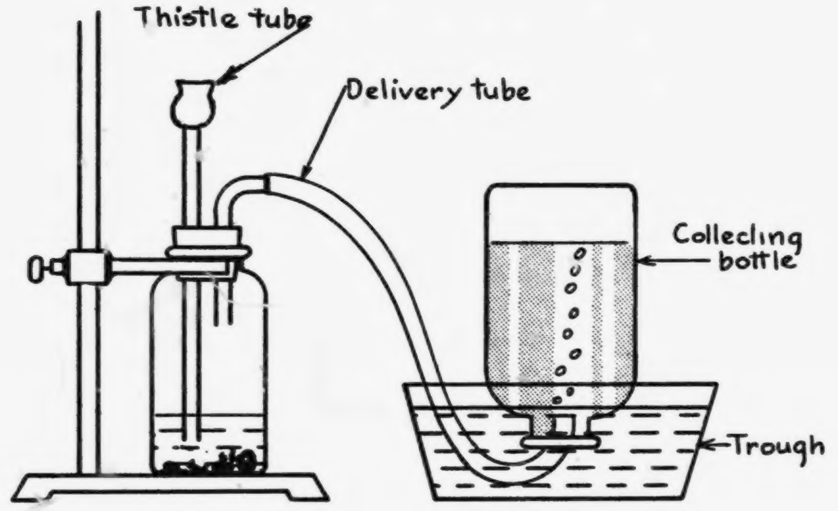
Motivation

Insert an iron nail into a test tube containing about two inches of copper sulfate solution. After one minute, remove the nail and show it to the class.

Development

1. Help the pupils to identify the copper coating on the nail. Ask, "Where did the copper come from?" Write the equation for the reaction on the board: $Fe + CuSO_4 \longrightarrow Cu + FeSO_4$
2. Elicit that during the reaction, the iron changed places with the copper and was set free. Identify this as a *single replacement reaction.*

3. Collect two bottles of hydrogen gas by the water displacement method, using mossy zinc and hydrochloric acid in the generator.



Reject the first bottle collected. Test the second bottle with a lighted splint to prove that it is hydrogen. Show the formation of the white precipitate of zinc chloride in the generator.

4. Help the pupils to write the equation for the reaction on the board: $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

   Elicit that the zinc replaced the hydrogen. Explain that hydrogen often acts like a metal. Ask, "How should this reaction be classified?" Point out that the hydrogen which was replaced was set free.

5. *Write the equations for the electron exchanges during this reaction:*

   a. $HCl \longrightarrow H^+ + Cl^-$

   b. $Zn^\circ - 2e \longrightarrow Zn^{++}$

   c. $2H^+ + 2e \longrightarrow H_2 \uparrow$

   d. $Zn^{++} + 2Cl^- \longrightarrow ZnCl_2$

   In equation "a" we see that the acid ionizes. Equation "b" shows that the zinc atom gives up 2 electrons to become an ion (double positive charge). Equation "c" shows that the hydrogen ions accept the zinc electrons to become molecules of hydrogen gas; "↑" is the symbol for a gas. Equation (d) shows the combination of the zinc and chloride ions to form the white precipitate zinc chloride. The metal which gives up electrons (zinc) is more active than the metal which accepts the electrons (H).

Summary

1. A metal can replace a __________ (metal, nonmetal) in a compound.

2. The element which is replaced is __________ (combined, set free).

3. A __________ (metal, nonmetal) can replace hydrogen.

4. *The metal which is replaced is __________ (more, less) active than the metal which replaces it.*

5. *The more active metal __________ (lends, borrows) electrons.*

Homework

1. Write a word and symbol equation to illustrate each of the following types of reactions:

   a. synthesis b. decomposition c. single replacement

2. Complete the following reactions. Draw a box around the element which is replaced and a circle around the element which takes its place. $CuO + H_2 \longrightarrow$

   $Zn + Cu(NO_3)_2 \longrightarrow$ $Cu(NO_3)_2 + Fe \longrightarrow$

Materials

Iron nail
Test tube
Mossy zinc
Wood splints
Delivery tube
Water trough
Generator bottle
Copper sulfate solution
Dilute hydrochloric acid
2 gas collecting bottles
Thistle tube

15. WHAT HAPPENS WHEN TWO COMPOUNDS COMBINE?

Outcomes

- A *double replacement reaction* occurs whenever two compounds in solution react, and the metals replace one another.

- ***In a double replacement reaction, there is usually no gain or loss of electrons. There is a regrouping of the ions.***

Motivation

Display clear solutions of barium chloride and sodium sulfate. Add one solution to the other and have the class observe the white precipitate formed.

Development

1. Write the formula for each reactant on the board.

$$BaCl_2 + Na_2SO_4 \longrightarrow$$

2. Challenge the class to complete the equation and name the new compounds formed.

$$BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$$

Guide the pupils to realize that the metals barium and sodium exchanged places in the compounds. Identify this type of reaction as a *double replacement reaction.*

3. Ask, "What happens when salt (NaCl) is added to water?" Elicit that it dissolves and is invisible. Ask, "What is the white solid seen in the test tube?" Guide the class to identify the solid as barium sulfate, which is insoluble.

4. Repeat the demonstration using lead nitrate [$Pb(NO_3)_2$] and potassium chromate (K_2CrO_4). Have the pupils observe the yellow precipitate which forms, and help them write the equation:

$$Pb(NO_3)_2 + K_2CrO_4 \longrightarrow PbCrO_4 + 2KNO_3$$

Help the class identify the precipitate as lead chromate. Ask, "Where is the potassium nitrate?"

5. ***Recall that in a single replacement reaction the more active metal gives up electrons to the less active metal. However, in a double replacement, electrons are not exchanged. There is only a regrouping of the ions. As a result of any double replacement, one of the products will always be either a gas which escapes, an insoluble precipitate, or water. For example:***

a. $$NH_4^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ + Cl^- + H_2O + \underset{(gas)}{NH_3} \uparrow$$

b. $Ba^{++} + 2CL^{-} + 2Na^{+} + SO_4^{--} \longrightarrow$

$2Na^{+} + 2Cl^{-} + BaSO_4 \downarrow$ *(precipitate)*

c. $K^{+} + OH^{-} + H^{+} + Cl^{-} \longrightarrow K^{+} + Cl^{-} + H_2O$ *(water)*

Summary

1. $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$
   a. The precipitate is ________.
   b. The barium part of the product comes from the ________.
   c. The sulfate part of the product comes from the ________.
   d. This is a ________ ________ reaction.
2. $Pb(NO_3)_2 + K_2CrO_4 \longrightarrow PbCrO_4 + 2KNO_3$
   a. The precipitate is ________.
   b. The lead part of the product came from the ________.
   c. The chromate part of the product came from the ________.
   d. This is a ________ ________ reaction.
3. *In a double replacement reaction the ________ are regrouped.*
4. *One of the products of a double replacement reaction will be a ________, ________ or ________.*

Homework

1. Complete the equations and state the type of reaction (synthesis, decomposition, single replacement, or double replacement).
   a. $Na_2CO_3 + CaCl_2 \longrightarrow$ ________ $+ CaCO_3 \downarrow$
   b. $2Al + 6HCl \longrightarrow 2AlCl_3 + 3$____
   c. $2Cu + O_2 \longrightarrow 2$________
   d. $2HgO \longrightarrow 2$________ $+$ ____ $\uparrow$
   e. ________ $+ HCl \longrightarrow NaCl + H_2O$

Materials

Clear solutions of: Barium chloride — Lead nitrate
Sodium sulfate — Potassium chromate

16. HOW CAN WE TEST THE LAW OF CONSERVATION OF MATTER?

LABORATORY LESSON (OPTIONAL)

Outcomes

- In a chemical reaction, the weight of the reactants equals the weight of the products.
- In a chemical reaction, matter is neither created nor destroyed.

Development

1. Challenge the pupils to suggest ways in which they can test the Law of Conservation of Matter. Guide them to understand that we must either count or measure. Ask, "Why can't we count the atoms or molecules?" Elicit that we can measure the total weight at the start and at the end of a reaction.
2. Caution the pupils in the handling of silver nitrate which stains the skin.
3. Distribute the Worksheets and materials.

Summary

Refer to questions on Worksheet to reinforce concepts.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 16

Problem: How can we test the Law of Conservation of Matter?

Materials

Platform or triple beam balance
Test tube containing 10 mls of $AgNO_3$
Test tube containing 10 mls of $NaCl$
250 ml beaker
Test tube rack

Procedures and Observations

1. Stand the two test tubes containing the solutions in the beaker, and place the beaker on the balance.

2. Weigh carefully to the nearest 0.1 gram. Weight of beaker, test tubes, and solution is ____________ grams.

3. Remove the beaker from the balance and record your observations:
   a. The $AgNO_3$ appears (clear, cloudy) ____________.
   b. NaCl appears (clear, cloudy) ____________.

4. *Carefully* pour the sodium chloride (NaCl) solution into the test tube of silver nitrate ($AgNO_3$). Return both test tubes to the beaker.
   a. Did a reaction take place? ____________
   b. The appearance of the material in the test tube is ____________.

5. Reweigh the beaker containing the two test tubes.
   The weight of beaker and test tubes after mixing is ____________ grams.

6. Was there any change in weight? ____________

7. The equation for this reaction is:
   $AgNO_3 + NaCl \longrightarrow$ ____________ + ____________
   The precipitate is ____________.

Summary

1. The reactants were ____________ and ____________.

2. The products were ____________ and ____________.

3. The change in weight was ____________.

4. The Law of Conservation of Matter is true because ____________.

Homework ·

1. If you burn a piece of paper, the ash weighs less than the paper. Explain this fact according to the Law of Conservation of Matter.

2. Plan an experiment to prove the Law of Conservation of Matter. Use Worksheet form: Problem, Materials, etc.

17. HOW CAN WE SEPARATE A METAL FROM ITS OXIDE?

Outcomes

- Metals are extracted from ores.

- Many ores are metallic oxides.
- To obtain the pure metal, the oxygen must be removed.
- *The process by which oxygen is removed from a compound is called* reduction.

Motivation

Display samples of ores such as: hematite, smithsonite, galena, pyrite, bauxite, etc. Identify each by writing its name and formula on the board, e.g.,

hematite — Fe_2O_3
smithsonite — $ZnCO_3$
galena — PbS (fool's silver)
pyrite — FeS_2 (fool's gold)
bauxite — Al_2O_3
melaconite — CuO

Guide the pupils to understand that *ores* are naturally occurring minerals from which a pure metal can be extracted.

Development

1. Ask, "What must we do to obtain the pure metal?" Elicit that the nonmetal must be removed.
2. Demonstrate the process for removing a metal from its oxide as follows:
   a. Dig a hole in a charcoal block about ¼" to ½" across and ¼" deep. Place the carbon powder dug out of the hole on a piece of paper.
   b. Mix equal parts of copper oxide and carbon powder and pour the mixture carefully into the hole in the charcoal block. Pack the mixture into the hole.
   c. Use the blowpipe and burner to heat the mixture for two minutes.
   d. After the mixture cools, remove it to an asbestos pad. Ask a volunteer to look for small pieces of copper in the mixture.
3. Help the pupils write the equation for the reaction on the board.

$$2CuO + C \longrightarrow CO_2 + 2Cu$$

Ask, "What type of reaction is this?"
Point out that a single replacement is better than a simple decomposition which would require too much heat.

4. Tell the class that other ores are changed to oxides by roasting, and the metals are then extracted (removed) from the oxides.

   a. *roasting* — $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2 \uparrow$
      extraction — $2PbO + C \longrightarrow 2Pb + CO_2 \uparrow$

   b. *roasting* — $ZnCO_3 \longrightarrow ZnO + CO_2 \uparrow$
      extraction — $2ZnO + C \longrightarrow 2Zn + CO_2 \uparrow$

5. *Recall that whenever oxygen combines with an element or compound, the reaction is called oxidation. Whenever oxygen is removed from a compound the reaction is called a reduction. Roasting as shown in equation 4a above is an oxidation. The extraction is a reduction.*

Summary

1. An ore is a compound of sulfur, oxygen or carbonate, and a ______________.

2. If the ore is an oxide, the metal can be extracted by removing the ______________.

3. If the ore is not an oxide, ______________ is needed to change it to an oxide before the metal can be extracted.

4. The extraction is a ______________ ______________ type of reaction.

5. *When oxygen combines with a substance, the reaction is called* ______________.

6. *The removal of oxygen from a compound is called* ______________.

Homework

Write the equations to show how we can extract the metals from their ores:

a. Iron from hematite (Fe_2O_3)
b. Mercury from cinnabar (HgS)
c. Magnesium from magnesite ($MgCO_3$)

Materials

(Materials continued on next page.)

Samples of ores:

hematite
smithsonite
galena
pyrite
bauxite
melaconite, etc.

(Materials, continued)

Charcoal block
Triangular file
Copper oxide powder
Spatula
Bunsen burner
Blowpipe
Asbestos pad

REVIEW AND REINFORCEMENT (12-17)

Activities

1. Combine the following in as many ways as you can to formulate correct compounds.

H
Cu
NO_3
CO_3
Ni
O
Zn
Ca
S
OH
Cr
ClO_3
NH_4
PO_4
K
Cl
CrO_4
Hg
Ba
Fe
C
Al
P
Na
N
SO_4
Ag
Pb

Rate yourself on this list.

40 or more compounds — Chief chemist
35-40__________Chemist
30-35__________Laboratory assistant
25-30__________Laboratory technician
20-25__________Bottle washer
below 20________Student

2. Combine HCl with each of the items in column 1 on the chart. Write the equation for the reaction, and classify the type of reaction.

REACTANT	EQUATION	TYPE OF REACTION
Zn		
$AgNO_3$		
Cu		
$NaOH$		
NH_4OH		

Trips

Suggested places to visit where chemistry has a major role:

- Union Carbide (Man.)
- Charles Pfizer (Bklyn. & Man.)
- Hoffman La Roche (Nutley, N. J.)
- Hall of Science (Flushing)
- Good Housekeeping Institute (Man.)

◆

ACTIVITY OF METALS

Suggested Lessons and Procedures

18. ARE SOME METALS MORE ACTIVE THAN OTHERS?

Outcomes

- In general, the activity of the metals in a family increases as the distance between the outer electron(s) and the nucleus increases.
- In general, the activity of a metal within a period decreases as the number of electrons it can lend increases.

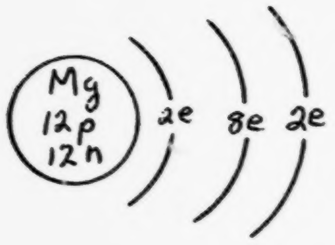
Motivation

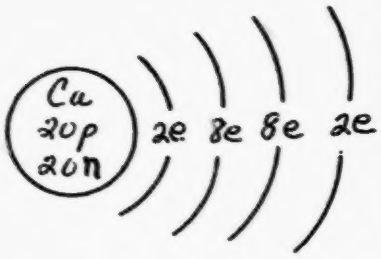
Briefly review the concept of a family of metals (Lessons 2 & 3). Place a 1-inch strip of magnesium ribbon and a small piece of calcium into separate test tubes, each half filled with water. Allow the two tubes to stand. Elicit that there is no observable reaction in either at this time. Instruct the class to continue watching the test tubes and to notify you as soon as some change occurs.

Development

1. Ask the pupils to suggest hypotheses as to what might happen in each test tube. Record their suggestions on the chalkboard.
2. Refer to the Periodic Table to elicit the following:
   a. Both magnesium and calcium are in Group II.
   b. Both have two electrons in the outer shell.
3. Draw the atom diagrams of both on the board. *(See next page.)*

   Referring to the atomic weight of each, elicit that the calcium atom has one additional ring of electrons. Ask, "Which atom would





hold its outer ring of electrons more tightly?" Establish that since the outer electrons of magnesium are closer to the positively charged nucleus, there is a greater attraction than in the calcium atom. Ask, "Which atom will give up its outer electrons more easily? Referring to the previous suggestions, ask, "Which hypothesis is most likely to be correct?"

4. Observe the test tubes to confirm that some calcium has reacted whereas the magnesium has not. Relate the observation to the atomic structure in that the calcium atom is more active than the magnesium atom since its outer electrons are more loosely held because of their greater distance from the nucleus. Guide the class to generalize this conclusion on activity for all the elements within each family of metals.

5. Recall that elements in Group I can lend one electron, Group II can lend two electrons, and Group III three electrons. Ask, "Which is easier, to lend one, two, or three electrons?" Guide the pupils to conclude that it is easier for Group I elements to lend the single electron. Therefore, we can expect Group I elements to be more active than Group II, and Group II to be more active than Group III. Generalize that in a particular period on the Periodic Table, the fewer electrons a metal atom has to lend, the more active the metal.

Summary

1. Within a family of metals, the greater the atomic weight, the __________ (more, less) active the metal.
2. Within the same family, the greater the distance between the nucleus and the outer electrons, the __________ (more, less) active the metal.
3. Within the same period on the Periodic Table, the more active element will have __________ (more, fewer) electrons to lend.

Homework

Complete the table by inserting the elements in order of activity. List the most active element first. Elements: aluminum (Al), sodium (Na), cobalt (Co), iron (Fe), potassium (K), beryllium (Be).

ELEMENT	ATOMIC WEIGHT	ATOMIC NO.	NO.: ELECTRON RINGS	ELECTRONS: OUTER RING
1.				
2.				
3.				
4.				
5.				
6.				

Materials

1" strip of magnesium ribbon	2 test tubes
Small piece of calcium	Periodic Table

19. HOW CAN WE PROVE THAT SOME METALS ARE MORE ACTIVE THAN OTHERS?

LABORATORY LESSON

Outcomes

- Because of their activity, *metals* can be listed in an *activity chart (or series).*
- A metal at the top of this list will replace those metals below it from their compounds in a chemical reaction.

Development

CAUTIONS:

1. Hold test tubes at a slant and slide the metal strips carefully into the solutions.
2. Spilled solutions should be cleaned up with a damp sponge immediately.

3. Use cool running water to wash off any solutions spilled on the hands. Reminder: Silver nitrate stains skin.

Distribute materials and Worksheets.

Summary

Refer to questions on the Worksheet to reinforce concepts.

Materials

0.3 N copper nitrate solution — $Cu(NO_3)_2$

0.3 N lead nitrate solution — $Pb(NO_3)_2$

0.3 N zinc nitrate solution — $Zn(NO_3)_2$

0.3 N silver nitrate solution — $AgNO_3$

Strips of zinc

Strips of copper

Test tubes and racks

> **Note**: To make 100 ml of a 0.3 N solution, dissolve:
>
> a. 5.1 gm $AgNO_3$ in 100 ml H_2O
>
> b. 2.9 gm $Zn(NO_3)_2$ in 100 ml H_2O
>
> c. 2.8 gm $Cu(NO_3)_2$ in 100 ml H_2O
>
> d. 5.0 gm $Pb(NO_3)_2$ in 100 ml H_2O

(May be duplicated for use by pupils)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 19

Problem: How can we prove that some metals are more active than others?

Materials

3 strips of zinc

3 strips of copper

6 labelled tubes, each containing one inch of solution:
- 1 tube — copper nitrate
- 1 tube — zinc nitrate
- 2 tubes — lead nitrate
- 2 tubes — silver nitrate

Procedures and Observations

1. Place one copper strip carefully into each of these solutions:

   a. lead nitrate b. zinc nitrate c. silver nitrate

   Return each test tube to the rack.

2. Place one strip of zinc carefully into each of the following solutions:

   a. lead nitrate   b. copper nitrate   c. silver nitrate

   Return each test tube to the rack.

3. Allow test tubes to stand for one minute. Remove the strip (one at a time) from each test tube, and record your observations below.

SOLUTION	METAL	METAL DEPOSITED	SOLUTION COLOR CHANGE
$Pb,(NO_3)_2$	Cu		
$Zn(NO_3)_2$	Cu		
$AgNO_3$	Cu		
$Pb(NO_3)_2$	Zn		
$Cu(NO_3)_2$	Zn		
$AgNO_3$	Zn		

Summary

1. Copper (replaces, does not replace) ____________ lead from lead nitrate.
2. Copper (replaces, does not replace) ____________ zinc from zinc nitrate.
3. Copper (replaces, does not replace) ____________ silver from silver nitrate.
4. Zinc (replaces, does not replace) ____________ lead from lead nitrate.
5. Zinc (replaces, does not replace) ____________ copper from copper nitrate.
6. Zinc (replaces, does not replace) ____________ silver from silver nitrate.
7. In a chemical reaction, the more active metal ____________ the less active metal.
8. Based on your observations, list the metals in order of their activity, with the most active one at the top.

ACTIVITY CHART
1.
2.
3.
4.

Homework

Refer to an *Activity of Metals* chart in your textbook (or one given to you by your teacher). Fill in the following:

1. Mg ____________ (does, does not) replace Al from compounds.
2. Fe ____________ (does, does not) replace Ag.
3. Pb ____________ (does, does not) replace H.
4. Na ____________ (does, does not) replace Li.
5. Sn ____________ (does, does not) replace Cu.

20. WHY DO SOME METALS CORRODE?

Outcomes

- The chemical wearing away of metals is called corrosion.
- The most common agents of corrosion are water, carbon dioxide, oxygen, and sulfur dioxide.
- Metals can be protected against corrosion by oiling, painting, plating, or forming alloys.
- *Corrosion may be explained as an electrochemical reaction.*

Motivation

Display samples or refer to examples of rusted iron, pitted chrome, tarnished silver, and green copper. Have the pupils examine these objects and elicit that these are evidence of the wearing away of metals. Ask, "How does this reaction cost us money?"

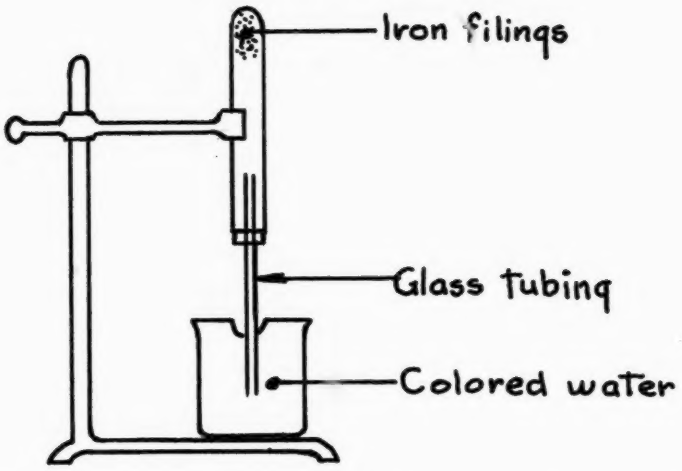
Development

1. Briefly discuss the need to replace metals which wear away on bridges, automobiles, homes, etc.

   Refer to grade 7 Chemistry "Rusting of Steel Wool," or repeat experiment if time permits.

2. Moisten the inside of a large test tube with dilute acetic acid. Add enough iron filings to form a thin layer on the inside of the test tube. Set up the apparatus as shown: *(Next page)*

NOTE: The acetic acid is used to speed up the oxidation. Set the apparatus aside. Check periodically for evidence of rusting and a rise in the level of colored water.



3. Ask, "Is rusting a chemical or physical reaction?" Establish that it is a chemical reaction which is called *corrosion.*

4. Refer to the demonstration and ask, "What causes iron to rust?" Elicit that the oxygen in the air combines with the iron to form rust (Fe_2O_3). Point out that water and carbon dioxide are also agents of corrosion because they supply oxygen for the oxidation of the metal.

5. Ask the class to suggest ways of protecting metals against corrosion. Develop that oiling, painting, and plating form a protective coating which prevents the oxygen in the air from reacting with the metal.

6. Display a piece of stainless steel and explain that it is a mixture of iron and chromium which is not affected by air or water. Identify such combinations of metals as *alloys.* Name several alloys such as bronze (Cu, Zn, Sn), duraluminum (Al, Cu, Mg), nichrome (Fe, Ni, Cr), and brass (Cu, Zn).

7. *Iron contains impurities. The thin film of water on its surface contains ions of hydrogen. The pure iron and its impurities behave like electrodes. The water acts like an electrolyte. Thus we have an electrochemical cell (similar to a wet cell) which produces the iron oxide or rust.*

Summary

1. The wearing away of metals is called ___________.
2. Some agents of corrosion are ___________, ___________, and ___________.

3. Metals can be protected against corrosion by __________, __________, __________, or __________.

4. Several common corrosion-resistant alloys are ________, ________, and __________.

5. *The rusting of iron can be explained as the formation of a __________ cell.*

Homework

Set up the following experiment at home to test the rusting of iron and its prevention.

a. Use two identical iron nails. Dip the nails into a small amount of vinegar. Set one nail aside and coat the other nail with vaseline or oil.

b. Allow both nails to remain in the air overnight.

c. Examine both nails and record your observations.

d. Write up the experiment, using the standard form for a laboratory report.

Materials

Rusted iron
Pitted chrome
Tarnished silver
Green copper
Large test tube
Dilute acetic acid

Iron filings
250 ml. beaker
Colored water (ink, $KMuO_4$, etc.)
Glass tubing (10″)
One-holed rubber stopper
Ring stand and clamp
Stainless steel

21. HOW DO WE USE DIFFERENT METALS IN THE HOME?

Outcomes

- The special properties of a metal determine its use.
- Some metals require special care to combat corrosion.

Motivation

Display one clean and one tarnished silver or silver-plated utensil. Ask, "Why is silver used to make flatware?" Elicit the properties such as malleability, luster, and color. Elicit some of the disadvantages of the metal such as heat conduction, tarnishing, and softness. Call attention to the tarnished utensil and ask, "How can we clean it?" Pupils may suggest polish, scrubbing, steel wool, etc., each of which tends to scratch or wear away the soft silver. Suggest that there is another way to clean the tarnish.

Development

1. Place the tarnished utensil into a 400 ml. beaker containing two teaspoons of baking soda ($NaHCO_3$), one teaspoon of salt ($NaCl$), a strip of aluminum foil and enough water to cover.

2. Heat to boil and allow it to cool. Remove the utensil and compare its appearance with the clean untarnished utensil. Briefly discuss some advantages of this method.

3. Ask, "What other metal can be used in place of silver?" Elicit that stainless steel is used because of its durability, hardness, and resistance to tarnish.

4. Ask, "What metals are used for plumbing in the home?" Help the pupils to include the following:

   Copper resists corrosion, bends easily, and conducts heat quickly.

   Iron is strong, inexpensive, but rusts easily.

   Lead is easily soldered and bent, but is too soft.

   Brass is harder than copper and more resistant to corrosion.

5. Ask, "What metals are used for pots and pans?" Lead the discussion to include:

   Aluminum conducts heat readily, is easy to clean, easy to shape, light in weight, and resists corrosion.

   Copper is used for bottoms of pans because it heats up very quickly.

   Chromium has a beautiful shine, but is hard to clean without scratching.

   Iron retains heat, but rusts and blackens.

Summary

1. List five properties of metals which make them suitable for use in the home.
2. Silver is used to make utensils because ______________________.
3. Stainless steel is more practical for utensils than silver because ______________________.
4. List three properties of metals which make them suitable for plumbing.
5. Three metals used in plumbing are __________, __________, and __________.
6. Select one metal used to make pots and pans, and name the properties of the metal which make it suitable.

Homework

1. List the metals used in making coins. Next to each metal list the properties which make it suitable.
2. List metals used in making jewelry. Next to each list the properties which make it suitable.
3. Name three additional uses of metals in the home. List the properties which help to determine which metal is used.

Materials

Silver or silver-plated utensils, tarnished and clean

2 teaspoons baking soda (Na_2CO_3)

1 teaspoon salt (NaCl)

Strip of aluminum foil

400 ml beaker

22. HOW CAN WE PLATE A METAL?

LABORATORY LESSON

Outcomes

- An object can be *plated* with metal by using electricity.
- The object to be plated is the *negative electrode.*

- The *electrolyte* contains metal ions which are deposited on the negative electrode.
- *A plating metal may be used as the positive electrode.*
- *To unplate an object, reverse the direction of current.*

Development

1. Caution the pupils to connect the dry cells in series and to leave the switch open until the circuit is checked by the teacher.
2. Distribute the Worksheets and materials.

Summary

Refer to questions on the Worksheets to reinforce concepts.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—CHEMISTRY: LESSON 22

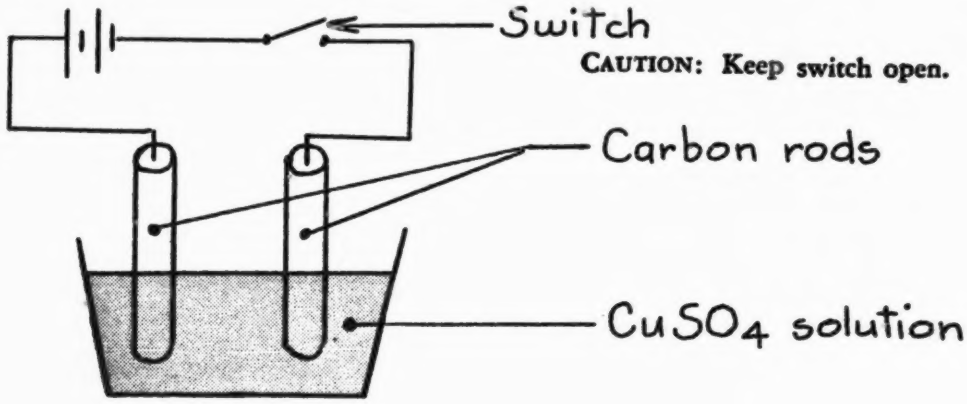
Problem: How can we plate a metal?

Materials

Two carbon rods
10% solution copper sulfate ($CuSO_4$)
Two dry cells
Bell wire
Porcelain collar for electrodes (if available)
400 ml beaker or jar

Procedures and Observations

1. Connect the carbon rods into the circuit as shown in the diagram.



CAUTION: Keep switch open.

2. After your teacher checks the circuit, close the switch. Allow the current to flow for 3-5 minutes. Open switch. Remove and examine electrodes.
   a. $CuSO_4$ in solution contains ____________ and ____________ ions.
   b. Copper ions are ____________ (positive, negative).
   c. Equation for ionization: $CuSO_4$ ____________$^{++}$ + ____________$^{=}$
   d. The carbon rod connected to the negative battery terminal is the ____________ (positive, negative) electrode.
   e. The carbon rod connected to the positive battery terminal is the ____________ (positive, negative) electrode.
   f. The $CuSO_4$ solution is an ____________ (electrode, electrolyte).
   g. The copper was plated on the carbon rod from the ____________.
   h. The positive copper ions are attracted to the ____________ (positive, negative) electrode.
   i. To plate a steel spoon we would connect the spoon to the ____________ (positive, negative) electrode.
3. *If this reaction were to continue for a long period, what would happen to the copper ions in the solution?* ____________

   What material should be used for the positive electrode to supply additional copper ions? ____________
4. *Replace the carbon rod which was the positive electrode with a cafeteria quality teaspoon. Reverse the battery connections to make the teaspoon the negative electrode and the copper-plated carbon rod the positive electrode. Close the switch for 3-5 minutes. Open the switch. Remove and examine the electrodes.*
   a. *The copper was plated on the* ____________.
   b. *How can the copper plating be removed from the carbon rod?*

   ____

Conclusions

1. An object can be plated with a metal by using ____________ energy.
2. The plating solution contains ____________ of the metal.
3. The object to be plated is made the ____________ (positive, negative) electrode.
4. To plate silver on an object, we need silver ____________ in the solution.
5. To plate chromium on an object we need ____________ ____________ in the solution.
6. *To remove a metal plate, we* ____________ *the direction of current.*

Homework

1. Describe how you would silver-plate a teaspoon. Write it up in proper laboratory form.

Hints: a. The teaspoon is connected as the ___________.

b. The electrolyte contains ___________ ions.

c. ___________ energy is needed.

◆

REVIEW AND REINFORCEMENT (18-22)

Test

Read this passage and answer the questions which follow.

> Shipbuilders know better than to use brass screws when building the iron hull of a ship. After being in salt water, the screws would become a spongy mass, with as much strength as if they were made of steel wool. Since the day metal ships were first built, shipbuilders have been careful about placing different metals close to each other. An amateur shipbuilder who puts an iron rudder on a boat together with a bronze propeller is in for a shock. Within a few weeks the iron rudder would look as if something had bitten chunks out of it. In time, the rudder would disappear altogether. The iron rudder and the bronze propeller would act as two electrodes in a battery. The chemical reaction, similar to that of a wet cell, would cause the iron to corrode and dissolve in the sea water, while the bronze propeller would remain unharmed. Most large modern ships have blocks of magnesium or zinc attached to the iron parts. These blocks corrode first, and thereby protect the iron. Metallurgists, scientists who specialize in the chemistry of metals, were responsible for discovering these facts.
>
> The Telstar II communication satellite is an example of the work of metallurgists. There are more than thirty different metals and alloys used in making the satellite. These metals include gold, silver, platinum, and rare metals such as germanium. New uses for special metals are being dis-

covered daily. There is a great future in metallurgy for young chemists.

1. Write a suitable title for the reading selection.
2. What happens to brass screws attached to the metal hull of a ship in salt water?
3. Why don't shipbuilders put two different metals close to one another?
4. What would happen to an iron rudder near a brass propeller?
5. Describe the reaction that takes place between the iron and brass.
6. How are the iron parts of modern ships protected from corrosion?
7. What does a metallurgist do?
8. How was Telstar II an example of the work of metallurgists?
9. Name three common metals used in Telstar.
10. Name a rare metal used in Telstar.

Suggested Topics for Reports

1. The Manufacture and Uses of Swedish Steel
2. Manufacture and Use of Alnico Steel
3. The Thirty Metals and Alloys Used in Telstar
4. The Solar Battery
5. Transistors
6. Methods of Refining Metals

AV Material

Suitable AV materials may be obtained by writing to:

U. S. Steel Corp.

Alcoa Aluminum, Inc.

Union Carbide Corp.

Bethlehem Steel Corp.

Anaconda Brass and Copper Corp.

◆

23. WHAT ARE THE CAUSES OF WATER POLLUTION?

Outcomes

- Water is polluted by both nature and man.
- Water pollution is harmful to living things.
- Water pollution can be prevented or controlled.

Motivation

Cite several examples of water pollution:

1. In parts of New York City, foam from detergents backed up into sinks as high as the seventh floor.
2. People living on Long Island were surprised to find a fishy, oily taste in their water.
3. Garbage, dumped in the Atlantic Ocean, was found floating in the Hudson River.

Ask, "What caused the pollution in each of these cases?"

Development

1. Briefly discuss the causes of the pollution cited above:
    a. Man-made detergents are widely used in place of soap. Have the pupils name some familiar detergents and soaps. Unlike soaps, detergents resist the action of bacteria to break them down. Therefore detergents tend to accumulate in the water system.
    b. Polluted waters kill fish. The odor of decaying fish and fish oils gets into the drinking water.
    c. The wastes from incinerators are dumped at sea. The tides carry these wastes back toward land and into the Hudson River and other rivers.
2. Additional causes of man-made pollution may be discussed:
    a. Recently an oil tanker broke up and sank off San Juan Harbor in Puerto Rico. The oil floated up on to the beaches. The drinking water was also contaminated. Many efforts were made to get rid of the oil by use of detergents and by burning.

b. A large chemical company was dumping 100,000 tons of aluminum chloride down the drain with the waste water from the plant. The aluminum chloride killed fish and polluted the drinking waters. The problem was solved by removing the aluminum chloride before dumping the water. The company now sells this compound to a paper mill for a profit.

3. Natural pollution can also occur. Surface waters contain CO_2 which is dissolved from decaying living things. The CO_2 reacts with the water to form carbonic acid (H_2CO_3) which attacks limestone and changes it into calcium bicarbonate [$Ca(HCO_3)_2$]. Other compounds such as magnesium bicarbonate [$Mg(HCO_3)_2$] and iron bicarbonate [$Fe(HCO_3)_2$] may also be formed. These bicarbonate compounds cause hardness of water. Well water contains much of these bicarbonates. The drinking water in some areas of New York City comes from such wells.

Summary

1. Name four ways in which man causes pollution of water.
2. Why do detergents pollute water?
3. What causes water to have a fishy, oily taste?
4. How do wastes get into the waters around New York City?
5. How can water pollution be prevented or controlled?
6. How does the natural pollution of water occur?

Homework

1. The city of Syracuse draws its drinking water from Lake Skaneateles. The lake is used for boating and swimming.
   a. List possible causes of water pollution.
   b. How can the lake pollution be prevented or controlled?
2. What are some of the harmful effects of water pollution on man?

Materials

Pictures and newspaper clippings on water pollution.

Booklet "Our Polluted World" — American Education Publications

24. WHY ARE WATER SOFTENERS USED?

Outcomes

- Ground water is naturally polluted by the formation of bicarbonates.
- There are disadvantages in the use of water containing bicarbonates.
- Water softeners remove bicarbonates from solution.

Motivation

Prepare some hard water before the lesson by dissolving two teaspoons each of magnesium bicarbonate and calcium bicarbonate in 500 ml of water. Display a brightly polished aluminum pan. Boil the hard water in the pan, pour off the water, and show the discoloration produced by the hard water. Ask, "What caused this discoloration or scale?"

Development

1. Boil 20 ml of a 10% calcium bicarbonate solution [$Ca(HCO_3)_2$] in a test tube. Ask the class to observe the formation of the precipitate as a coating on the inside of the test tube. Write the equation for the reaction on the chalkboard:

   $$Ca\ (HCO_3)_2 \xrightarrow[\text{(Heat)}]{\Delta} CaCO_3 \downarrow + H_2O + CO_2 \uparrow$$

   Calcium bicarbonate → calcium carbonate + water + carbon dioxide

   Identify the precipitate as calcium carbonate and elicit that the gas carbon dioxide escapes.

2. Refer to the previous lesson to review the process by which bicarbonates are formed in ground water. Explain that approximately 80% of the available water in our country contains bicarbonates. Such water is called *hard water*.

3. Introduce other disadvantages of hard water as:

   a. Soap does not "suds up" in hard water because the metal ions in the water combine with the soap to form "metal soap."

   b. Boiler scale forms inside pipes carrying heated water. This solid, rock-like precipitate eventually clogs the pipe.

c. Some hard water which contains iron bicarbonate $[Fe(HCO_3)_2]$ will cause rust-like stains on laundry and sinks.

4. Water softeners change these bicarbonates to carbonates in the same way as boiling. To demonstrate, add a small amount of slaked lime to some of the hard water to precipitate the carbonate. Write the equation on the chalkboard:

$$Ca(OH)_2 + Ca(HCO_3)_2 \longrightarrow 2CaCO_3 \downarrow + 2H_2O$$

Ask the class to name some popular commercial water softeners such as borax, Calgon, etc.

Summary

1. Ground water is naturally polluted by ____________.
2. Water containing bicarbonates is called ____________ water.
3. Boiling hard water changes the bicarbonates into ____________.
4. Name three possible problems in the use of hard water.
5. A chemical which changes the bicarbonates in water to carbonates is called a ____________ ____________.

Homework

1. Fill three glasses, each half full of water. To the first, add a small amount of detergent. To the second, add an equal amount of soap flakes or soap powder, and to the third, add a pinch of water softener and the same amount of soap as before. Stir each glass and observe the volume of suds produced. Answer the following questions:
   - a. Which glass contains the most suds?
   - b. Which glass contains the least suds?
   - c. Do water softeners improve sudsing? Why?
2. Research problems:
   - a. How does soap clean dirty laundry?
   - b. What properties of detergents make them more popular than soaps?
   - c. How are detergents manufactured?

Materials

Hard water [dissolve 2 teaspoons each of $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ in 500 ml H_2O]
Polished aluminum pan
40 ml of 10% $Ca(HCO_3)_2$ solution
½ gm slaked lime [$Ca(OH)_2$]
Test tube and holder
Test tube rack

CHEMISTRY UNIT REVIEW

Multiple Choice

Use the following information to answer questions 1 to 6:

Atomic Number 11 *Atomic Weight 23*

1. How many neutrons are in the nucleus of this atom?
a. 11 b. 12 c. 22 d. 23 e. 34

2. How many protons are in the nucleus?
a. 11 b. 12 c. 22 d. 23 e. 34

3. How many electrons are in the second shell?
a. 11 b. 18 c. 2 d. 8 e. 32

4. The total number of electrons present in a neutral atom of this element is:
a. 11 b. 12 c. 22 d. 24 e. 34

5. During a chemical change an atom of this element will tend to:
a. lose 1 electron b. gain 1 electron c. gain 2 electrons
d. lose 2 electrons e. remain neutral

6. This element will have the chemical properties of:
a. a metal b. a nonmetal c. a radio-active element
d. a compound e. a mixture

7. When group II metals combine, they will:
a. lend 2 electrons b. borrow 2 electrons c. lend 6 electrons
d. lend 8 electrons e. lend 1 electron

8. An atom whose valence number is -3 will:
a. lend 3 electrons b. lend 5 electrons c. borrow 3 electrons
d. borrow 5 electrons e. not react

9. The valence of calcium in the compound $CaCl_2$ is:
   a. +1 b. −1 c. +2 d. −2 e. −3

10. Aluminum has a valence of +3; the formula for the oxide of aluminum is:
   a. Al_3O b. OAl_3 c. Al_3O_2 d. Al_2O_3
   e. none of these

11. When a metal reacts with an acid, it:
   a. gains protons b. loses protons c. gains electrons
   d. loses electrons e. none of these

12. The case of a dry cell battery is made of:
   a. iron b. copper c. chlorine d. hydrogen e. zinc

13. The valence of iron in $FeCl_2$ is +2; the valence of iron in $FeCl_3$ is:
   a. +2 b. −2 c. +3 d. +5 e. −1

14. The atom group, SO_4 is called a:
   a. atom b. element c. compound d. radical e. oxide

15. The compound Na_2CO_3 will dissociate to form:
   a. $Na + CO$ b. $2Na + CO_2$ c. $2NA^{+} + CO_3^{=}$
   d. $Na + C + O$ e. $NaC + O_3$

16. The valence of ammonium is +1; the valence of phosphate is −3; the correct formula for ammonium phosphate is:
   a. Am_3PH b. $(NH_4)_3PO_4$ c. $NH_4(PO_4)_3$
   d. NH_3PO_3 e. NH_4PO_4

17. The formula for a compound is Ag_2S. Its name is:
   a. silver sulfate b. sulfur silvide c. gold sulfide
   d. silver sulfide e. silver sulfur

18. The atomic weight of iron is 56. The atomic weight of oxygen is 16. The formula weight of the compound $Fe_2\,O_3$ is:
   a. 16 b. 56 c. 72 d. 104 e. 160

19. The equation $2KClO_3 \longrightarrow 2KCl + 3O_2\uparrow$ represents an example of:
   a. ionization b. combination c. decomposition
   d. double replacement e. synthesis

20. The equation $2H_2 + O_2 \longrightarrow 2H_2O$ represents an example of:
a. ionization b. synthesis c. decomposition
d. single replacement e. double replacement

21. The equation $Zn + 2HCl \longrightarrow ZnCl_2 + H_2\uparrow$ is an example of:
a. ionization b. synthesis c. decomposition
d. single replacement e. double replacement

22. Of the following, the equation which represents a double replacement reaction is:
a. $Ca + CO_2 \longrightarrow CaCO_2$
b. $2Na + 2H_2O \longrightarrow H_2 + 2NaOH$
c. $2\ HgO \longrightarrow 2Hg + O_2$
d. $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$
e. $HCl \longrightarrow H^+ + Cl^-$

23. After a flashbulb is used, the total weight of bulb and contents:
a. remains the same b. decreases slightly c. increases slightly
d. increases noticeably e. decreases noticeably

24. To extract a metal from a sulfide ore, it must first be changed into:
a. a sulfate b. an oxide c. a chloride
d. a carbonate e. a phosphate

25. To extract the metal from an oxide, the metal must be heated in the presence of:
a. carbon b. chlorine c. neon d. helium e. fluorine

26. Which member of this family of metals is the most active?
a. $_4Be^9$ b. $_{12}Mg^{24}$ c. $_{20}Ca^{40}$ d. $_{38}Sr^{88}$ e. $_{88}Ra^{226}$

27. The chemical wearing away of a metal is called:
a. erosion b. ionization c. melting d. corrosion
e. plating

28. Rusting may be prevented by:
a. oiling b. painting c. plating d. all of these
e. none of these

29. Which of the following is the metal most widely used in making pots and pans?
a. platinum b. uranium c. gold d. silver e. aluminum

30. Ground water becomes naturally polluted by the presence of:

a. carbonates b. bicarbonates c. chromates
d. bisulfides e. chlorates

Matching

Match the items in Column A with items from Column B.

Column A	*Column B*
1. Valence	a. Compound of metal and sulfur
2. Radical	b. $2H_2 + O_2 \longrightarrow 2H_2O$
3. Rust	c. $Ag^2NO_3 + NaCl \longrightarrow NaNO_3 + AgCl$
4. Sulfide	d. combining ability
5. Water Pollutant	e. $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$
6. Synthesis	f. Corrosion
7. Double Replacement	g. Negative particle in atom
8. Ore	h. Hematite
9. Single Replacement	i. $Ca(HCO_3)_2$
10. Electron	j. PO_4
	k. Positive particle in atom

Completion

1. The valence of magnesium is two. The atom will have ________ electrons in its outer shell.

2. When NaCl and $AgNO_3$ react, a solid ________ is formed.

3. Valence tells us the number of ________ an atom can lend or borrow.

4. A ________ is a group of elements which act like a single atom.

5. Atoms with more than one valence are called ________ atoms.

6. Metals combine with ________ to form compounds.

7. All compounds which are made of two elements end in the suffix ________.

8. The sum of the atomic weights of all the atoms in a compound is called ________.

9. In a chemical reaction, the total weight of __________ must equal the total weight of the products formed.

10. A reaction in which a compound is broken down into simpler substances is called __________.

SUGGESTED REFERENCES: CHEMISTRY

For the Teacher

BRISCOE, HERMAN T. *An Introduction to College Chemistry*. Boston: Houghton Mifflin, 1957.

BROWNLEE, RAYMOND, and others. *Elements of Chemistry*. Boston: Allyn and Bacon, 1958.

CARLETON, ROBERT H., and others. *Chemistry for the New Age*. Philadelphia: Lippincott, 1954.

COOPER, ELIZABETH. *Discovering Chemistry*. New York: Harcourt, Brace, 1959.

DORF, HAROLD, et al. *Chemistry for the Nuclear Age*. New York: Oxford, 1965.

DULL, CHARLES, and others. *Modern Chemistry*. New York: Holt, Rinehart & Winston, 1962.

JAFFE, BERNARD. *Chemistry Creates a New World*. New York: Crowell. 1957.

JOSEPH, ALEXANDER, and others. *A Sourcebook for the Physical Sciences*. New York: Harcourt, Brace and World, 1961.

WEAST, ROBERT C. *Handbook of Chemistry and Physics*. Cleveland, Ohio: Chemical Rubber Co., 1966.

WEAVER and FOSTER. *Chemistry for Our Times*, 3d ed. New York: McGraw-Hill, 1960.

For the Pupil

Asimov, Isaac. *Building Blocks of the Universe.* rev. ed. New York: Abelard-Schuman, 1961.

Asimov, Isaac. *The Search for the Elements.* Basic Books, 1962.

Aylesworth, Thomas G. *Our Polluted World.* Middletown, Conn.: American Education Publications, 1968.

Davis and Day. *Water, The Mirror of Science.* New York: Anchor Books, 1961.

Feifer, N. *Let's Explore Chemistry.* New York: Sentinel Books, 1959.

Green, Lillian. *Water.* New York: Coward-McCann, 1958.

Hyde, Margaret O. *Molecules Today and Tomorrow.* New York: McGraw-Hill, 1963.

Kendall, James. *Great Discoveries by Young Chemists.* New York: Crowell, 1954.

McCabe, C. L. and Bauer, C. L. *Metals, Atoms, and Alloys.* New York: McGraw-Hill, 1964.

Morgan, Alfred. *First Chemistry Book for Boys and Girls.* New York: Scribner, 1950.

Nourse, A. E. and Webbert, J. C. *So You Want to Be a Chemist.* New York: Harper and Row, 1964.

Urell, Catherine. *Big City Water Supply.* New York: Follett, 1953.

Unit III
EARTH SCIENCE

Astronomy
Solar System
Energy in the Solar System
Man and Space

ASTRONOMY

Suggested Lessons and Procedures

1. WHY DO WE STUDY ASTRONOMY AND SPACE SCIENCE?

Outcomes

- Man explores space to gain information about Earth's place in the universe.
- Man will use this information gained in space to understand more about the Earth.

Motivation

In recent years the United States government has spent billions of dollars on our space program. Why is our government willing to spend so much money on this program?

Development

1. To emphasize how man has already made use of various spacecraft, show pictures of different types (probes, satellites and capsules), and elicit how each is adapted or may be used to secure information. Examples:
   a. Satellites for weather predictions
   b. Experiments to show how man functions in space
   c. Operations of missiles for defense
   d. Moon survey and exploration
   e. Radiation experiments

2. Tell class that scientists know about the motions of the planets, predict eclipses, and establish tide tables through the study of astronomy. Man has gained a better understanding of physical laws through observations.

3. Elicit the ways in which man has used the stars for navigation and map making. Show recent photographs of the Earth taken by astronauts which confirm our original ideas about its size and shape.

4. Elicit the necessity for accurate time. Point out that all time is measured by the motions of celestial bodies. Tell class that all clocks are set with clocks housed in astronomical observatories.

5. Point out that international cooperation in the study of space and astronomy lead to better human relations among the various countries.

6. *Introduce the historical aspects of space exploration and assign reports on such topics as Goddard, Tsiolkovsky, IGY, Sputnik, Explorer, and other related space programs.*

Summary

1. List several reasons why it is important to have space and astronomy programs.

2. List some space programs and tell what each is attempting to do.

3. *Challenge the pupils to explain the following: "Earth is the cradle of the mind, but one cannot live in the cradle forever."*

Homework

For each *space program* listed, match the purpose which best fits that program. There may be more than one answer.

Purposes

a. Human Endurance
b. Weather Conditions
c. Navigation on Earth
d. Operations of Satellites for Defense
e. Confirmation of Physical Laws
f. Further Exploration into Space
g. Communication

Space Program

1. A satellite (Tiros) takes pictures of the Earth's cloud cover. ____________
2. During IGY a satellite sent back information to Earth. ________
3. A TV show in England is broadcast live to the United States. ____________
4. Mariner recorded information about Venus. ____________
5. Ranger space probe takes closeup pictures of moon. ____________
6. Surveyor analyzes lunar surface. ____________
7. John Glenn was given many tasks during his orbital flight. ____________
8. Sputnik's path around Earth was tracked by many stations in different countries. ____________
9. High altitude pictures of Earth. ____________

2. HOW DO MIRRORS AND LENSES ENABLE US TO STUDY ASTRONOMY?

Outcomes

- Telescopes are instruments used in astronomy.
- Modern telescopes not only magnify objects but also collect light.
- A refractor telescope uses lenses while a reflector telescope uses mirrors to gather light.

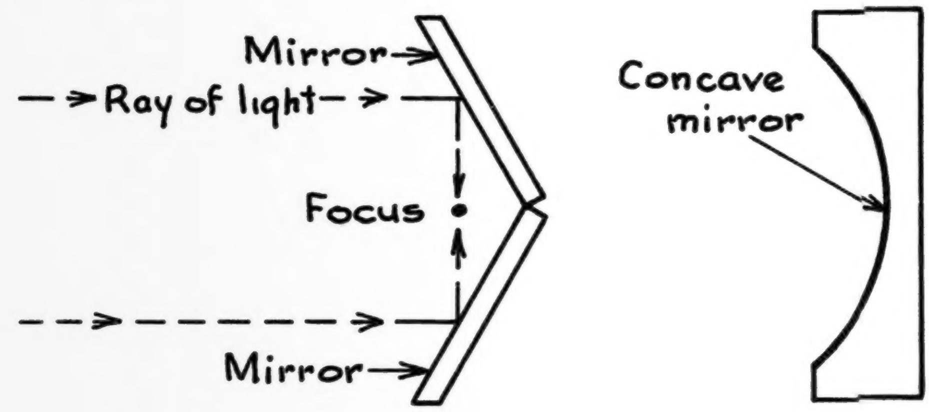
Motivation

Using the Blackboard Optics Kit (14-5938), review the behavior of light in relation to lenses and mirrors. Refer to grade 9 Physics unit on lenses.

Development

1. Elicit that in order to observe distant bodies we must first collect the light given off by the objects.

2. Demonstrate the light-gathering properties of convex lenses with the use of the Optics Kit.
3. Show the class a telescope and/or binocular. Identify the convex lenses.
4. Using the Optics Kit, demonstrate how light converges to a focal point with a concave mirror.
5. *Recall the law of plane mirrors where the angle of incidence equals the angle of reflection. Draw two mirrors at right angles to each other and point out the similarity to a concave mirror. Show both reflected rays converging to a point on the principal focus.*



6. Demonstrate the plane and concave sides of a microscope mirror. Elicit which side would be used to produce a brighter light. Why?
7. By means of a transparency, show how the optics of a refracting and reflecting telescope gather light and magnify objects. (See items 3 and 4.)
8. *Enrich the lesson by analyzing types of images formed: real or virtual, erect or inverted, small or large. Show pictures of actual optical telescopes in use.*

Summary

1. Why can you see more stars with a telescope than without one?
2. What is the purpose of the mirror in a reflecting telescope?
3. Why are most observatories located on mountain tops?
4. *Explain the relation of mirror size with the amount of light collected.*

5. *What are the advantages of the reflecting telescope over the refracting telescope? (Glass does not have to be perfect since no light passes through; only one side of the glass mirror has to be ground; it is easier to support.)*

Homework

1. Make a list of 5 objects found around your home that resemble the mirror used in a reflecting telescope. (Hint: flashlight.)
2. Obtain a convex lens and burn a hole in a piece of paper by directing the sun's rays on the paper. Why can this be done?
3. *Why does an astronomer find it useful to use a camera in conjunction with a telescope.*

3. HOW CAN WE CONSTRUCT AND USE A REFRACTING TELESCOPE?

LABORATORY LESSON

Outcomes

- Most celestial bodies are so far away that looking directly at them may not be very informative.
- A telescope gathers the light from a star.
- The refracting telescope includes an objective lens which forms an image of a distant object very close to our eyes.
- The eyepiece lens is used to magnify the very small image.

Motivation

Hold up some printed material in front of the room. Ask pupils why is it so difficult to read the material from their seats. Have them suggest methods which could be used to make it more legible.

Development

1. Recall the two types of telescopes.

2. Ask, "What would you need in order to construct a refracting telescope?"
3. Distribute materials to each group of pupils. Guide the pupils in performing the laboratory activity.

(MAY BE DUPLICATED FOR USE BY PUPILS)

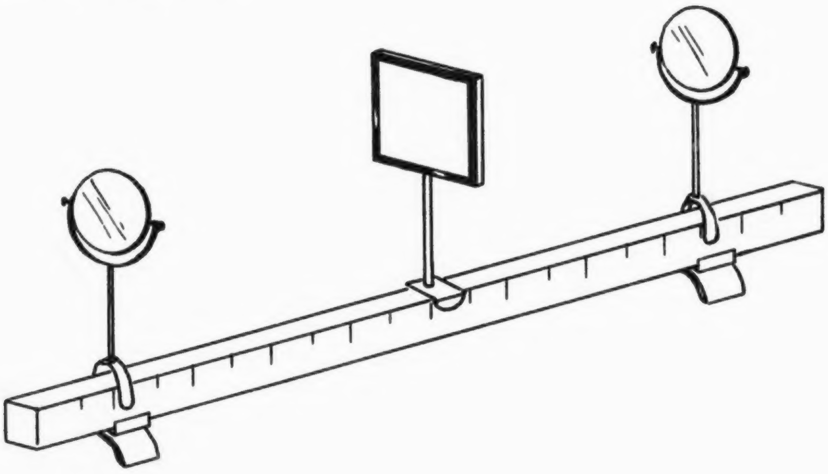
LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 3

Problem: How can we construct a refracting telescope?

Materials

Eyepiece lens — 10cm, convex
Objective lens — 30cm, convex
Cardboard screen with piece of translucent paper in center or, frosted glass (see diagram)
Meterstick
Lens holders, screen holder
Burette clamp
Stand

Procedure and Observations



1. Mount the meterstick on the stand.
2. Mount the screen near the center of the stick.
3. Using a lens mount, place one lens on the meterstick in front of the screen.
4. Select a fairly distant object, such as a tree or house, through the classroom window.
5. Move your lens back and forth until you see the clearest possible picture of the object on your screen.

a. How does the image formed on the screen resemble the original object?

____

____

b. How does the image formed on the screen differ from the original object? ____

____

6. Carefully measure and record the distance between the screen and the lens. (The focal length of a convex lens is the distance from the lens to the focus.) Focal length of the lens is ____________ cm.

   Replace the lens #1 with lens #2.

7. Repeat the same procedure with the second lens placed at the opposite end of the meterstick. Focal length of second lens is ____________ cm.

8. Now place both lenses at the proper focal lengths on opposite sides of the screen. Then observe the object on the screen through the lens with the small focal length.

   a. Describe the image now formed on the screen. ____________________

   ____

9. Without touching the lenses, remove the screen from the stick, and look through the eyepiece.

   a. Why can you still see the image? ____________________

   ____

10. Turn your telescope around and use the eyepiece lens as the objective lens. Does this make viewing better or poorer? Why? ______________

    ____

    ____

Conclusions

1. Why do we use a telescope to observe celestial bodies?
2. What is the function of the objective lens in the refracting telescope?
3. What is the advantage of having a larger objective lens?
4. What is the function of the eyepiece lens?
5. Why are the lenses of a refracting telescope enclosed in a tube?

Homework

1. Draw a diagram of a refracting telescope, indicating the path taken by the light entering the telescope.
2. *Calculate the M.P. of your telescope.*

$$\text{(Magnifying Power) M.P.} = \frac{\text{focal length of objective lens}}{\text{focal length of eyepiece lens}}$$

3. *Explain how a mirror can be used to construct a telescope.*

4. CAN LIGHT BE USED TO DETERMINE THE COMPOSITION OF CELESTIAL BODIES?

Outcomes

- A spectroscope is an instrument which can be used to study light.
- Each element has its own special spectrum.
- Many elements found on Earth have been detected on other celestial bodies.

Motivation

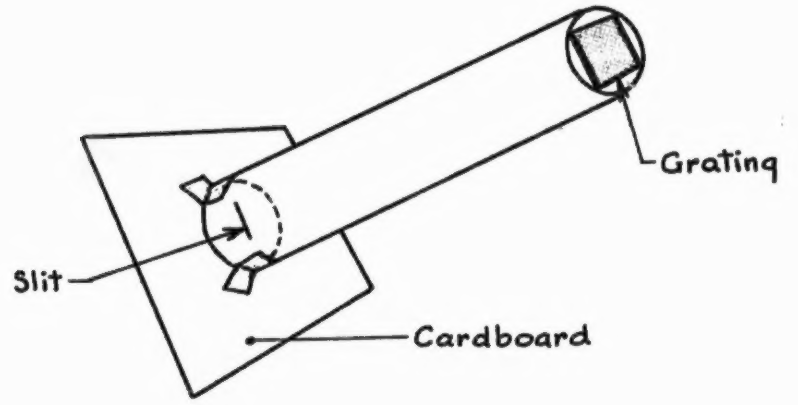
Wet the tip of a nichrome loop wire and place it into sodium chloride so that the powder will stick to it. Hold this in the blue flame of a Bunsen burner. Have the students note the color of the flame. Repeat this procedure using other compounds such as strontium chloride and copper sulfate. Elicit that the colors observed in these flame tests can be used to recognize certain elements in these compounds such as sodium, strontium, and copper.

Development

1. Recall from the 9th grade Physics unit the way in which a glass prism forms a spectrum from white light that comes from the sun. Stress that they were studying the sun's spectrum.
2. If available, show the class a *spectroscope* or a picture of one, and its various parts. Explain that this instrument allows scientists to study a spectrum with greater precision.
3. Ask the students what would happen if only yellow light is sent through a glass prism. (The result is a spectrum of one band only, yellow light.)
4. Place large crystals of sodium chloride on a wire screen. Set this on a stand over a Bunsen burner. Have students come up and view

the spectrum with a hand spectroscope.

Note: A hand spectroscope can be made by inserting a diffraction grating at one end of a cardboard tube. Cut a piece of cardboard to fit the other end of the tube. Cut a very narrow slit 1⁄32″ wide and ¾″ long in this piece of cardboard and position it on the tube so you get a horizontal spectrum. When using this spectroscope, aim the slit at the colored flame. As you hold it a few inches away (be careful not to burn it), the flame should almost cover the slit.



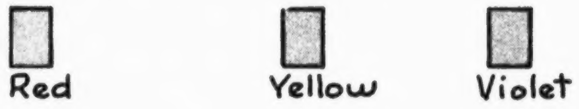
5. Exhibit a chart of the continuous spectrum of the sun and one of the bright line emission spectrum of sodium. Point out that sodium always produces the same two yellow lines in the same place when it is heated to a gas and viewed through a spectroscope. Explain that each element or compound has its own spectrum. Relate this to fingerprinting as a method of identifying individuals.

6. Point out that by matching the spectrum of a star or the sun with the spectrum that a particular element produces in the laboratory (comparison spectrum), the astronomer can tell whether the star contains that element. More than sixty elements have been found in the sun, each one identified by its fingerprint, its spectrum.

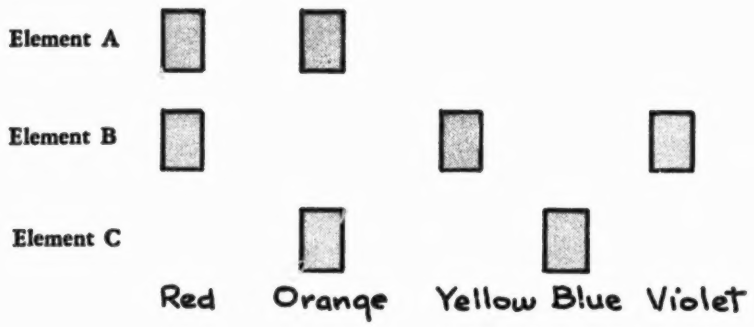
Summary

1. What instrument do astronomers use along with a spectroscope?

2. You look through a spectroscope at a star and see this spectrum of an unknown element.



You then compare it with the following table of known spectrums. Name the unknown element by its letter.



Homework

1. What does a spectroscope analyze?
2. How does the spectroscope enable us to analyze the sun?
3. Describe two methods that could be used to analyze an unknown chemical.

5. HOW CAN INTENSITY OF LIGHT FROM A CELESTIAL OBJECT BE USED TO DETERMINE ITS DISTANCE AND SIZE?

Outcomes

- If we have two luminous objects of the same temperature and at the same distance from us, the larger object will appear brighter.
- Stars are made up of hot gases that cause them to be luminous.
- If a luminous object is brought closer to us, it will appear brighter.
- As the temperature of a glowing object increases, it becomes brighter.

Motivation

In a darkened room, light a Bunsen burner (with a yellow flame) and a small birthday candle near each other. Have students compare the intensity (how bright) of the two flames visually.

Development

1. Elicit from the pupils that stars are made up of hot gases that give off heat and light. Tell them that all of the stars do not have the same brightness.
2. Develop from the motivation that the intensity of light from a star can determine its size.
3. Show class a photoelectric meter. Point out that the meter confirms the visual sighting. Have a student determine the intensity of the flames with the meter.
4. Have a student direct a lighted flashlight on a meter from various distances. Have students observe the points reached on the meter. Develop the concept that intensity of light decreases with distance.
5. Hold a piece of nichrome wire in a flame. Have students note that the longer you hold the wire in the flame the brighter the wire glows. Show them that as the wire cools, the intensity lessens. Elicit that stars also have the same property.
6. Point out that a small star may be closer than a larger star and that both may have the same intensity.
7. *Demonstrate and discuss parallax as a method of determining distance by telling the pupils to hold a pencil at arm's length. Tell them to look at it with one eye alone and then with the other. Have them note that the pencil seems to move when viewed in relation to a distant object (chalkboard). Now have them move the pencil closer, repeat, and note the greater apparent displacement. (See* N. Y. S. Earth Science Handbook *5.28)*
8. *Point out that stars have different colors conditioned by the star's temperature. Have pupils recall the color of wire heated in a Bunsen flame, and the color of metal being welded.*

Summary

1. What is a star?
2. List 3 things that could determine the intensity of light from a star.
3. Star A and star B are the same distance from Earth, yet star B is brighter. What is true of star B?
4. Why does our sun appear to be the brightest star in the sky?

5. *Betelgeuse is the name of a bright red star. It is a very, very distant star. What can you tell about this star?*
6. *Explain how you could devise a system of describing stars in terms of intensity (absolute and relative magnitude).*

Homework

1. Why do some stars appear dimmer than others?
2. Why does the planet Jupiter, which shines by reflected light, appear brighter than many stars?
3. *A giant star is close and has a low intensity. What is its color?*
4. *How can a spectroscope be used to determine the temperature of a star?*

Materials

Bunsen burner
Birthday candle
Matches
Photoelectric meter
Flashlight
Nichrome wire

◆

REVIEW AND REINFORCEMENT (1-5)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

I. Topics for Reports

1. The Radio Telescope
2. Space Programs
3. Famous Astronomers and Their Contributions
4. Doppler Effect
5. Various Types of Stars (color, size, distance)
6. Star Magnitudes
7. Measurement of Distances in Astronomy

II. Test: Matching

1. refracting telescope
2. very hot star
3. reflecting telescope
4. Tiros
5. spectrum lines
6. apparent brightness of star
7. spectroscope
8. small star
9. focal length
10. telescope tube

a. instrument which analyzes light
b. large concave mirror to collect light
c. weather satellite
d. not very bright
e. object lens is convex so that it may collect light
f. cuts out excess light
g. fingerprints of the elements
h. depends upon distance from earth
i. high intensity (very bright)
j. distance from lens to focus

III. Films And Filmstrips

The following films are available from the BAVI Loan Collection.

Charting the Universe with Optical and Radio Telescopes. 13 min. Color. E.B.F., 1963.

Astronomy, like the other sciences, depends on observation, analysis, and insight.

Astronomer, The. 14 min. Color. I.F.B.

Methods and tools used by today's astronomers to determine the relationships of objects in space.

What Are Stars Made of? 15 min. Color. I.F.B.

Presents a comprehensive picture of the methods and tools the astronomer uses to learn about the stars in the universe.

Universe, The. 26 min. McGraw-Hill.

A clear, accurate and common basis for building a concept of the cosmos. How an astronomer goes about his job.

The following may be purchased. They are from the list of approved audio-visual materials prepared by BAVI.

Universe. (Film) Item 622.5. 20 min. National Film Board of Canada.

Astronomy — scope of our universe and the galaxies beyond.

Why Explore Space? (Film) Item 667.575. 16 min. Churchill Films.

Raises questions in science and social studies.

Astronomer at Work. (Filmstrip) Item 37410.61. McGraw-Hill.

How astronomers use instruments in their study of the heavens.

Man Becomes an Astronomer. (Filmstrip) Item 40050.14. E.B.F.

History of astronomy from its beginning to the present.

Astronomy. (Filmstrip) Item 39140.11. Prentice-Hall.

The component parts of the solar system: galaxies, planets, meteors, comets, man-made satellites.

◆

SOLAR SYSTEM

Suggested Lessons and Procedures

6. WHERE DOES THE SUN GET ITS ENERGY?

Outcomes

- In an ordinary chemical change, atoms combine by transferring or sharing electrons.
- In a nuclear fusion reaction, the nuclei of atoms are combined.
- The sun converts its hydrogen nuclei into helium and energy by a process known as nuclear fusion.
- In a thermonuclear reaction some matter is converted into tremendous amounts of energy.

Motivation

Hold up a match, a piece of coal, and some kerosene. Ask "What is common to all of these items?" Elicit that they are things that can burn. Burn the match. Have a student write a chemical equation for this reaction:

$$\text{Carbon} + \text{Oxygen} \longrightarrow \text{Carbon Dioxide}$$
$$C + O_2 \longrightarrow CO_2$$

Development

1. Ask the class what they observed during the reaction. Elicit that light and heat were given off and the match was consumed after a short period of time. Refer to the 9th grade Chemistry unit to point out there was an exchange of electrons during a chemical reaction.
2. Elicit that the sun also gives off heat and light. Develop that if the sun were to undergo a similar reaction, it would have burned out long ago.

3. Point out that the type of reaction taking place on the sun is not an ordinary chemical reaction involving electrons. Ask what other part of the atom is involved. Elicit that this is a nuclear reaction involving the particles in the nucleus of the atom. These particles are protons and neutrons.

4. Recall that by use of a spectroscope, scientists believe the sun is composed mainly of hydrogen and helium. Elicit that the sun is very large (864,000 miles in diameter) and that there is tremendous pressure and heat near the sun's core.

5. Have students see what happens when you press two pieces of clay together. Have them compare this to what might occur to the hydrogen nuclei near the sun's core. (Hydrogen nuclei are fused together.) Elicit the term *fusion* as the type of nuclear reaction this would be called.

6. Write the nuclear reaction: $4\ H^1 \longrightarrow He^4$ on the chalkboard. Show that the weight of the reactants (four hydrogen atoms = $4 \times 1.0081 = 4.0324$) is greater than that of the product (one helium atom = 4.0039). Ask, "What has happened to this lost weight?" (Lost weight converts to huge amounts of energy.)

7. *To help pupils visualize the great amount of energy produced by fusion, point out that Einstein developed an equation,* $E = mc^2$, *which shows that a small mass multiplied by the square of the speed of light (a very large number) will yield a large amount of energy.*

Summary

1. How does a nuclear reaction differ from a chemical reaction?
2. What is the source of the heat and light of stars?
3. Explain how during a nuclear reaction some of the matter may be changed into energy.
4. *How can man make use of thermonuclear reactions on the earth?*

Homework

1. How has knowledge of nuclear energy revealed much about the sun?

2. The sun is made up of more than 90 percent hydrogen. Why is this of vital importance to life on Earth?

3. Why do we call a nuclear fusion reaction thermonuclear?
4. *What are problems involved in creating thermonuclear reactions on the Earth?*
5. *What is the difference between nuclear fission and nuclear fusion?*
6. *Report on the probabilities of the sun's dying out.*

Materials

Matches **Kerosene** **Coal** **Clay**

7. HOW DOES THE SUN AFFECT US ON EARTH?

Outcomes

- The sun is the source of all our energy.
- Green plants need sunlight to make food. As a result, oxygen is also produced.
- The rays of the sun can affect the body in various ways.
- Sunlight provides the energy that may cause chemical reactions.

Motivation

Ask the pupils what might happen if the sun were to stop shining. "Would life be possible on this Earth?"

Distribute blueprint paper (3x3) to each pupil. Instruct each to place the paper, blue side up, at the corner of his desk. Have each one place an object such as coin, hairpin, or key on top of paper and let it stand for about 15-20 minutes.

Development

1. List the pupil responses on the board. Point out that many types of energy are either directly or indirectly related to the sun. Trace some of their suggestions to the activity of the sun.
2. Exhibit a green plant. Ask "What one activity do green plants engage in every day that scientists have failed to duplicate?" Refer to 7th grade Biology unit. Write the word *photosynthesis* on the

board and discuss the changes green plants make when they capture the sun's energy. (Green plants in the presence of sunlight make carbohydrates and oxygen from carbon dioxide and water.)

3. How do the ultraviolet rays of the sun cause people to tan regardless of skin color? Elicit from the students that ultraviolet rays cause *all* people to tan by stimulating special skin parts to produce a colored pigment called melanin; the only exception is the albino.

4. How are ultraviolet rays beneficial?
   a. Have students recall 7th-year concept of sunlight producing vitamin D in the body.
   b. Food preservation.

5. What are the harmful effects of ultraviolet light?
   a. Eye damage
   b. Harmful burns by initial overexposure (value of suntan lotions)
   c. Skin cancer from long overexposure

6. Refer to the 8th grade unit on weather. Develop with the students how today's weather is dependent upon the sun's energy.

7. Have pupils remove the objects from the pieces of blueprint paper. Ask if they can explain what happened. Elicit that sunlight caused the unprotected paper to fade or lose its color. Discuss the effects of sunlight on materials. Relate how store owners often hang huge plastic (amber-colored) sheets in their windows to protect the merchandise.

8. *Prepare a solution of silver nitrate or silver bromide and have class observe how it darkens in sunlight. Discuss its use in photography.*

Summary

1. Name some items used in your home. How did the sun's energy help to make these items?
2. How do plants and animals depend on each other and the sun?
3. What is the effect of sunlight upon our skin? Is it true of all races? What are the exceptions?
4. A concave mirror concentrates light to a focal point. How could this be used to harness the sun's energy?

5. *How can we trace the energy in a piece of coal to the sun?*
6. *What factors of weather are determined by the sun?*

Homework

1. How do we depend on the sun for all our food?
2. List five ways in which the energy of the sun affects our everyday life.
3. What are some ways to prevent burning of our skin during a summer day?
4. Explain why certain chemicals are kept in dark bottles.
5. *Is all sunlight visible? Explain your answer.*

Materials

Blueprint paper
Green plant
Silver nitrate solution
Test tube

8. HOW DOES THE MOON'S MOTION CAUSE IT TO CHANGE IN APPEARANCE?

Outcomes

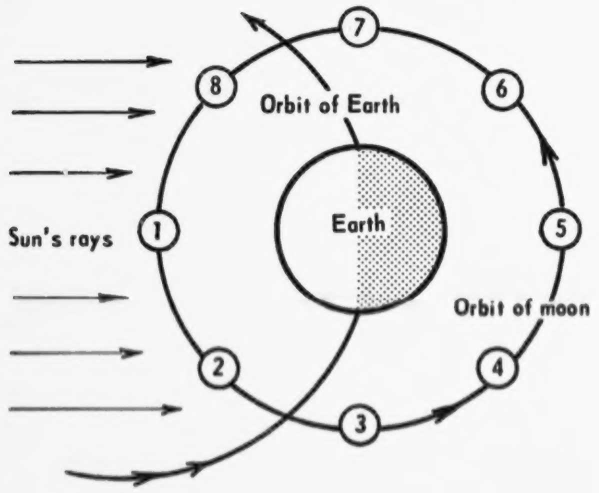
- The moon shines by reflecting the light which it gets from the sun.
- The same side of the moon is always seen from Earth because the moon revolves and rotates at the same speed.
- The phases of the moon depend on the positions of the Earth, sun, and moon.
- The phases change because of the moon's revolution around the Earth.

Motivation

Have the pupils note the various phases of the moon from the daily newspaper or calendar. Ask students to try to identify from a chart or an astromural which phase occurred the previous night.

Development

1. Point out that the moon shines by reflecting the light from the sun.
2. By means of the Tripansee Planetarium, show the class that the moon revolves around the earth. Have one of the students walk around the classroom in a counterclockwise direction, with a slate globe (representing the moon) held so that one face (marked with an X) always faces the class. Elicit that the same side of the moon is always seen because the moon's period of revolution and rotation are equal.
3. Place on the laboratory table a slate globe representing the moon and a slide projector representing the sun. Project the beam of the slide projector from various positions onto the globe. Have the students observe the different phases of the moon as the positions of the Earth, sun, and moon are changed.



Position of moon	Appearance	Phase
1		
2		
3		
4		
5		
6		
7		
8		

4. By means of a transparency or a chart, show how the moon in various positions appears to an observer on Earth.
5. *Using the diagram, elicit the hours of the day the various phases of the moon may be seen.*
6. *Discuss that various cultures have used, and are still using, the moon as a way of keeping time.*

Summary

1. What causes the moon's phases to change during the month?

2. Explain why one side of the moon always faces the Earth.
3. *During the crescent phases of the moon, we see the brightly illuminated crescent. Why is it also possible to see the rest of the moon, although dimly? (Earthshine: sunlight reflected from the daytime side of Earth onto the dark portion of the moon.)*
4. *If you were on the moon, would the Earth exhibit phases? Explain.*

Homework

1. Observe the moon for the next 4 weeks through telescopes, binoculars, or the naked eye. Keep a record of the various phases and the dates they occur. Make drawings of the appearance of the moon every fourth day.
2. Why is it possible for us to see the moon during the day?
3. *If astronauts established a camp on the moon, how often would they see the Earth? How long would they see it each time?*

Materials

Tripansee Planetarium	Slate globe	Projector

9. WHAT CONDITIONS DETERMINE SOLAR AND LUNAR ECLIPSES?

LABORATORY LESSON

Outcomes

- When the Earth passes between the sun and the moon, a lunar eclipse occurs.
- When the moon passes between the sun and the Earth, a solar eclipse occurs.
- The moon's orbit around the Earth is inclined with respect to the Earth's orbit around the Sun.

Motivation

Recall or tell the incident of the solar eclipse in Mark Twain's *Con-*

necticut Yankee in King Arthur's Court. Develop that the blackout of the sun's light is called an eclipse.

Development

1. Distribute materials to each group of pupils and explain that they will study the conditions similar to those when an eclipse occurs.

Materials

Flashlight	6″ styrofoam ball
Ping-pong ball suspended on stand	

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 9

Problem: What is the cause of lunar and solar eclipses?

Materials

Flashlight	6″ styrofoam ball
Ping-pong ball suspended on stand	

Procedures and Observation

1. Shine a flashlight on the large ball. Move the ping-pong ball into the shadow formed by the large ball.
   a. The large ball represents the Earth, the ping-pong ball the moon, the flashlight the sun.
   b. Which body has become eclipsed to a person standing on the Earth?
2. Move the ping-pong ball between the flashlight and the large ball so that the shadow of the ping-pong ball falls on a small section of the large ball.
   a. Which body has become eclipsed to an observer in the shadow area?
3. The shadow which the moon or Earth forms is called its umbra.
   Draw a picture of how the moon would look to an observer in this position
4. The moon's orbit is slightly inclined with respect to the plane of the Earth's orbit. How does this show us that a total eclipse of the moon will not occur once a month?

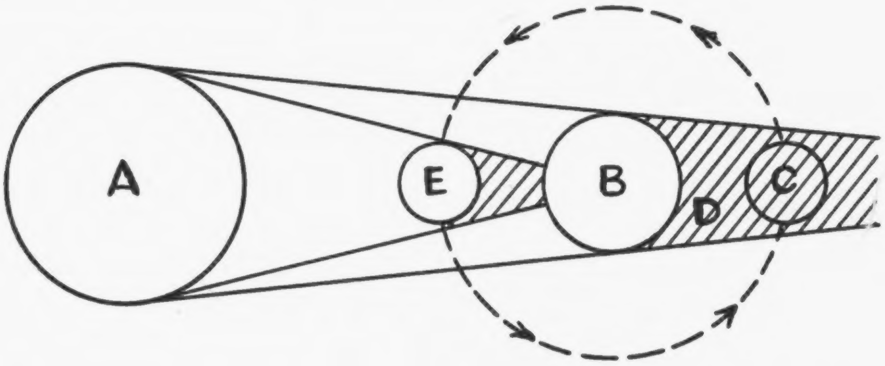
Conclusion

1. A lunar eclipse occurs when the *(moon, Earth, sun)* moves into the *(moon's, Earth's, sun's)* umbra.

2. A solar eclipse occurs when the *(moon, Earth, sun)* moves into the *(moon's, Earth's, sun's)* umbra.
3. At which phase of the moon do we get a total lunar eclipse?
4. At which phase of the moon do we get a total solar eclipse?
5. Why don't we get a total lunar eclipse each month?
6. *Explain why a lunar eclipse can be seen by more people than a solar eclipse even though both occur as often.*

Homework

1. Label the indicated parts of the diagram.



A_______ B_______ C_______ D_______ E_______

2. At which position is the moon during a lunar eclipse?
3. At which position is the moon during a solar eclipse?
4. Why is it dangerous to look at a solar eclipse?
5. *Suppose that the Earth's umbra is 6000 miles in diameter at the point where the moon crosses it. If the moon moves through it at 2000 miles per hour, how long will the lunar eclipse last?*

◆

REVIEW AND REINFORCEMENT (6-9)

The teacher may select the most suitable of the following suggestions for review and reinforcement.

Test

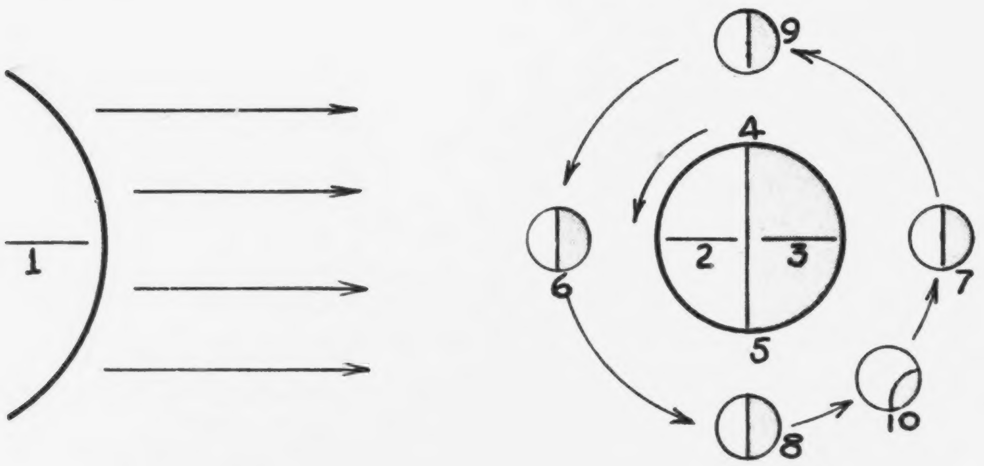
1. The chief source of the Earth's energy is (a) uranium decay (b) electricity from water power (c) electricity from chemical batteries (d) the sun.

2. The sun converts its hydrogen nuclei into helium and energy by the method of (a) fission (b) fusion (c) electron transfer (d) radiation.

3. Einstein's equation for the transfer of mass to energy is
   (a) $a^2 + b^2 = c^2$ (b) $V = f\lambda$ (c) $E = mc^2$ (d) $a = \pi r^2$

4. Label the diagram with the words from this list.

sunrise	nighttime on the earth
daytime on the Earth	full moon
sun	new gibbous
new moon	last quarter
sunset	first quarter



5. During which phase of the moon will we get a total lunar eclipse?
   (a) full (b) new (c) gibbous (d) crescent

6. At which phase of the moon will a total solar eclipse occur?
   (a) full (b) new (c) gibbous (d) crescent

Suggested Project

1. Sunspots are easily observed on a projected image of the sun. CAUTION: *Never look at the sun through a telescope or binoculars.*

Set up a telescope (or binocular) so that it can be directed at the sun and then remain fixed in that position. Prepare a 12- to 15-inch circular disk of cardboard with a hole in the center. Place this over the telescope (binocular). Now mount a 3 x 5 card behind the eyepiece lens of the telescope (binocular) about one foot perpendicular to the beam of light. The bright disc which shows up on the card is the sun's image. Look for sunspots on the image.

Topics for Reports

1. Statistics of the Sun
2. Regions and Features of the Sun
3. Energy and the Sun's Future
4. Features of the Moon and Lunar Conditions

Films and Filmstrips

The following films are available from the BAVI loan collection.

Energy from the Sun. 11 min. E.B.F., 1956.

How the sun acts as a source of energy which is utilized on Earth.

Mystery of the Sun. 27 min. Carousel, 1960.

Use of rockets as a new approach in the study of astronomy; in measuring x-rays, and the sun's ultraviolet rays.

Our Nearest Star (Planet Earth Series). 27 min. McGraw-Hill.

The properties of the sun and relationship of solar activity to Earth are explained. The effect of particles and radiations from the sun on man's environment is analyzed.

Eclipse. 10 min. Almanac, 1950.

Pictures and actual solar eclipse using time-lapse photography.

Sun's Energy. 12 min. Color. Cenco.

Discusses the different types of radiant energy supplied by the sun and how they affect us on Earth.

The following may be purchased. They are from the list of approved audio-visual materials prepared by BAVI.

Sun and How It Affects Us. (Film) Item 583.05. 10 min. Coronet.

Sun: its size, distance from Earth, effect on life and weather on Earth, and theory of Sun's origin.

Energy from the Sun. (Film) Item 194.22. 16 min. McGraw-Hill.

A series of energy conversions showing the sun to be the ultimate source. Fusion of hydrogen into helium.

Earth's Nearest Neighbor. (Filmstrip) Item 36245.1. S.V.E.

The nature of the moon and its relationship to the sun and Earth.

Moon. (Filmstrip) Item 39680.15. McGraw-Hill.

Size, shape, motions, and eclipses of the moon; the causes of tides.

Rocket to the Moon. (Filmstrip) Item 37410.53. McGraw-Hill.

The moon, its position in space, its phases, its shape, surface features, and methods of space flight.

The Sun and Its Energy. (Filmstrip) Item 39947.18. S.V.E.

How the sun releases energy; how energy reaches Earth; how we use it.

◆

ENERGY IN THE SOLAR SYSTEM

Suggested Lessons and Procedures

10. HOW DO WE EXPLAIN THE MOVEMENT OF HEAVENLY BODIES?

Outcomes

- An object at rest tends to remain at rest.
- An object in motion tends to remain in motion.
- The tendency of an object to maintain whatever motion it has originally is called inertia.
- Inertia keeps celestial bodies in motion.

Motivation

Hollywood made a science fiction movie entitled *The Day the Earth Stood Still.* Ask if anyone has seen this picture. Ask class to speculate about what would happen if the earth did stand still.

Development

1. By placing a plastic tablecloth with a place setting of dishes (may be plastic), silverware, etc., on a smooth table, demonstrate that an object at rest tends to remain at rest. Quickly jerk the cloth forward, leaving the dishes undisturbed (some practice may be necessary). Ask the class why the dishes did not fall. Have students give other examples of this principle, such as a subway train starting quickly.

2. Elicit that an object in motion tends to remain in motion by placing a marble or ball in a box open at one end. Push the box a short distance. Stop the box and ask why the ball keeps rolling after the box has stopped.

3. Relate the fact that inertia keeps celestial bodies in motion by asking the class to explain if there is any possibility that the earth and other planets could become fixed motionless bodies. Ask, "Why do the Earth and other celestial bodies keep moving?"

Summary

1. Explain why
   a. You fall backwards in a bus when it starts.
   b. You fall forward in a bus when it stops.
   c. A safety device is placed in cars that applies to inertia.
   d. A boy can catch a fast baseball with a catcher's mitt, but the same ball might break fingers if caught with bare hands.
2. Why does a space capsule require little fuel once it has gotten out into space?
3. How does the Law of Inertia explain why planets continue to move in space?

Homework

1. Place a card on top of a glass. Place a nickel or quarter on top of the card. Pull or flick the card quickly. What happens to the coin? Explain why.
2. *A book is suspended by a light thread just strong enough to support it. A similar string is tied below it. If you jerk the bottom string quickly, which string will break? Why? Pull steadily on the bottom string. Which string breaks now?*

Materials

Plastic tablecloth
Dishes
Tableware
Cardboard box
Small ball or marble

11. HOW DO GRAVITY AND INERTIA EXPLAIN THE ORBITING MOTION OF BODIES IN SPACE?

Outcomes

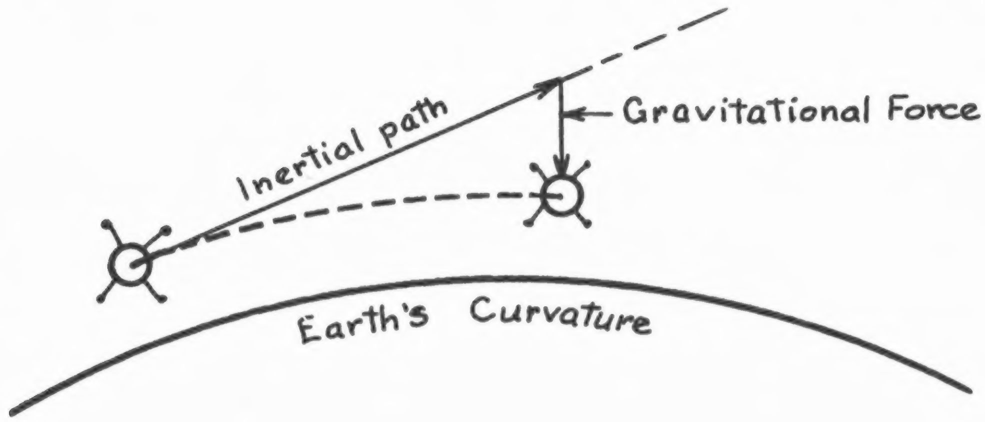
- Gravity holds celestial objects in orbit.
- To remain in orbit an object must attain a certain orbital velocity.
- *Orbital velocity changes with altitude.*

Motivation

Throw a ball into the air. Ask, "What causes the ball to stop its motion and fall back towards the earth?" Point out that gravity is a force of attraction that the earth has on all objects.

Development

1. Discuss the effects of an outside force, such as gravity, on objects in motion.
2. Tie a string to an object and whirl the object around your head. Elicit why the object follows a circular path and does not fly off. (A moving object normally follows a straight line because of inertia, but gravity as represented by the string changes the directions of all bodies so they move in a curve.)
3. *Discuss centripetal force as a force which tends to pull a moving object toward a center of rotation.*
4. Using the chalkboard as a background, throw a ball horizontally at different velocities. Students will note the ball takes a curved path and strikes the ground at different places. Elicit that gravity is the force acting on the ball, curving it towards the earth.
5. Review and draw a diagram of the curvature of the earth's surface. Ask, "What would happen if we were able to throw the ball fast enough so the path of the falling ball was to equal the curvature of the earth?" (The object will orbit the earth because the earth's surface curves downward as fast as gravity causes the object to approach the earth.
6. *By means of a diagram, show how an artificial satellite stays in orbit by falling around the Earth.*



7. *Develop that the greater the altitude of an orbiting body, the less velocity it requires to maintain orbit. This is because of the decreases in gravitational attraction due to distance.*
8. Point out that all members of our solar system are in motion. Elicit the reason for their orbital path.

Summary

1. What 2 factors keep the moon in orbit?
2. Explain how an artificial earth satellite can be put into orbit.
3. Explain why some artificial satellites are no longer orbiting the earth.
4. *Does a satellite at an altitude of 2,000 miles require less velocity or greater velocity than one at an altitude of 400 miles? Why?*

Homework

1. What would happen to an object that follows a path less curved than the curvature of the earth?
2. Based on today's lesson, explain why the planets orbit the sun.
3. If an astronaut were to walk out of his orbiting spaceship, would he remain in orbit? Why?
4. *Why is it so difficult for 2 orbiting satellites to approach each other by speeding up?*
5. *What do you think are the velocities of various planets as they are further from the sun?*

Materials

Ball	Lightweight object on string

12. HOW DOES GRAVITATIONAL ATTRACTION CAUSE TIDES?

Outcomes

- The periodic rise and fall of water on Earth is called tides.
- An attraction between any two objects in space is known as a gravitational force.
- As the distance between two objects increases, the gravitational attraction decreases.
- Two high tides occur each day.

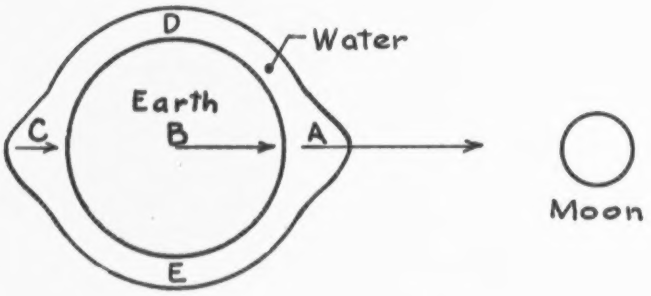
Motivation

Ask, "If you are sunbathing near the water on the beach, why does it become necessary to move back from the shore after a time? Point out that the periodic rise and fall of water is called *tides*.

Development

1. Construct an earth-moon model by placing a small styrofoam ball (about 2 inches) on one end of an 18-inch dowel and a larger styrofoam ball (about 8 inches) on the other end. Be sure to make holes right through the balls, so that they slide freely on the dowel. Balance the model on a string attached to the dowel. Elicit that because Earth is more massive than the moon, the balance point would be much closer to Earth. (The actual balance point is about 1,000 miles inside Earth.)
2. Demonstrate that the earth-moon pair revolves about its common center of gravity as it orbits the sun. Have the students suggest what happens if the model is rotated quickly. (The styrofoam balls would slide off the stick.) Ask, "What then prevents Earth and moon from flying apart?" (Gravity between the Earth and moon counterbalances this outward force.)
3. Point out that as the distance between two objects increases the

gravitational force decreases. By means of the following diagram discuss the cause of tides.



Elicit that because of the gravitational attraction of the moon on Earth, the water on the near side of the moon at *A* is free to flow toward the moon. A high tide will result.

4. Elicit that at *C* the oceans and Earth are pulled less than at *A* because of their greater distance from the moon. Point out the gravitational force is less and does not balance the tendency of the oceans to fly out away from the rotating Earth-moon system. (The solid Earth cannot respond as much as the free-flowing water.) A high tide results at *C*.

5. Have students conclude that two low tides exist at points *D* and *E* by the withdrawal of water to the high tide locations at *A* and *C*. Point out that the two tidal bulges forming high tides stay approximately in line with the moon as Earth keeps rotating. Ask, "How many high tides will occur in New York each day?"

Summary

1. What is meant by the tides?
2. How does distance affect gravitational force?
3. Why do two high tides occur on opposite sides of the earth at the same time?
4. Where is the best place to observe the change of tides?

Homework

1. Check a daily newspaper and fill in the table below to show daily tides for one place for 3 days.

Place ______________________		
Date	Time of High Tides	Time of Low Tides

2. What would be the approximate number of hours between high and low tides for a given place?
3. Define ebb and flood tides.
4. What industries might be affected by tides?

Materials

Large styrofoam ball	1 dowel (18")
Small styrofoam ball	String

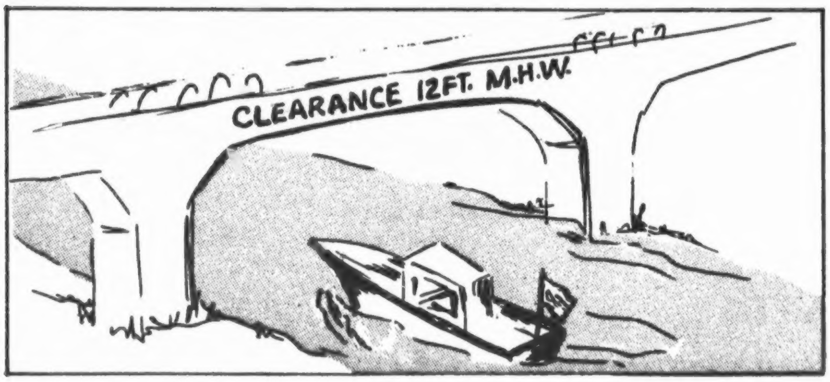
13. HOW DO TIDES DIFFER DURING THE MONTH?

Outcomes

- The moon and sun combine to produce a tide-raising force.
- A relationship exists between the phases of the moon and the tides.
- *Man makes use of this information about the tides.*

Motivation

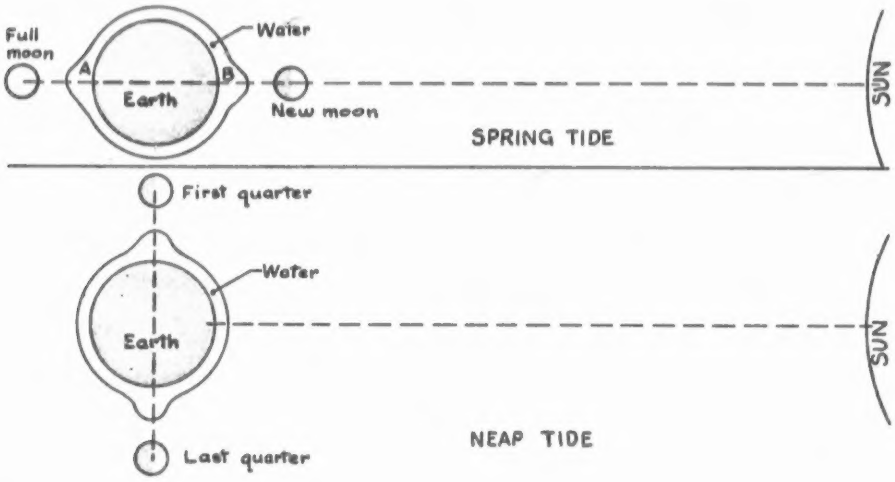
Draw the following picture on the chalkboard showing the clearance of a bridge above water.


CLEARANCE 12FT. M.H.W.

Ask, "Why must the sign specify mean (average) high water?" (High tide varies throughout the month.)

Development

1. By means of a tide chart and a calendar showing phases of the moon, develop that the range of low to high tides is usually greater during the new- and full-moon phases.
2. Review the idea that the gravitational force of the moon causes tides. Elicit that the sun also exerts gravitational forces on the Earth and that gravitational attraction decreases with distance. Point out that because of the sun's tremendous distance from Earth, its effect is only about half as great as the moon's.
3. By means of the following diagrams discuss spring and neap tides.


Full moon
Water
A
B
Earth
New moon
SUN
SPRING TIDE
First quarter
Water
Earth
SUN
NEAP TIDE
Last quarter

Elicit that at new moon, the sun and moon are pulling together to form unusually high *high-tides* and unusually low *low-tides.* At full moon, both the sun and the moon's gravitational forces act independently to cause high tides at *A* and *B*. The combined effect again is unusually high *high-tides* and unusually low *low-tides*. Have students suggest that at first and last quarter phases the sun's gravitational force is acting against that of the moon's to produce tides that have a small tidal range (difference in height between high and low tides).

4. Point out that the tidal range for most areas is just a few feet. Show pictures of the Bay of Fundy (tidal range is 60 feet) or other areas which have a great tidal range. Oceanographers believe one of the factors that cause great tidal range is water funneling into V-shaped bays from the open ocean.

5. *Ask, "How has man made use of his knowledge of the tides?" Guide the students to understand the following:*
   - *a. Tidal mill races are used in the production of electricity (Passamoquody Power Project in Maine).*
   - *b. Fisherman can make use of tide tables to increase their catch.*
   - *c. Boats sometimes must wait for high tide to pass through a channel.*

Summary

1. During which phase of the moon should the high tides be highest and low tides be lowest? Explain.
2. Why is the sun's effect on the tides not as great as the moon's?
3. *What kind of tides would result when perihelion and perigee (the point in the moon's orbit when it is closest to Earth) coincide with the full moon phase? Explain.*
4. What causes the tides to change? (Earth's rotation.)

Homework

1. Which celestial object has the greatest influence on the Earth's tides?
2. How many days separate a neap tide and the next spring tide? Why?

3. What is meant by slack water?

4. *How is it possible for tides to affect the speed of rotation of the earth?*

14. WHAT IS THE ORBITAL PATH OF THE EARTH AND OTHER MEMBERS OF THE SOLAR SYSTEM?

LABORATORY LESSON

Outcomes

- Earth and other bodies in our solar system orbit the sun in elliptical paths.
- An ellipse is an oval-shaped path.
- Aphelion occurs when Earth is at its greatest distance from the sun.
- Perihelion occurs when Earth in its orbit is nearest to the sun.

Motivation

Tie a string to a weight. Swing it around in a vertical plane. Ask the class to describe the shape of the orbit. Elicit that all points on a circular orbit are equidistant from the center. Have them note the length of the string at all times.

Development

1. Place the chart on the chalkboard and tell class that these are measurements of Earth's orbit from the sun at various dates. Ask, "What does this tell us about Earth's orbit with the sun at the center?" Point out that the shape of Earth's orbit is called an *ellipse*.

APPROX. TIME OF YEAR	APPROX. DISTANCE FROM EARTH TO SUN
March	93 million miles
June	94 million miles
September	93 million miles
December	91 million miles

2. Distribute materials to each group of pupils. Guide the pupils in performing the laboratory activity.

Materials

String	Weight

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 14

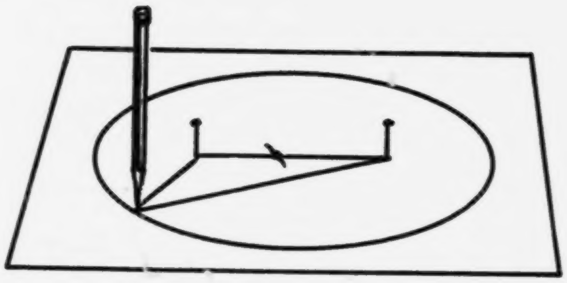
Problem: What is the orbital path of Earth and other members of the solar system?

Materials

Compass	8 x 10 unlined paper
String (about 8″ long)	8 x 10 cardboard
Tacks	Ruler

Procedure and Observation

1. Take your compass and draw a circle with a 2-inch radius at the top half of the page. Draw several lines from the center of the circle to its edge. Measure these lines.
   a. If the orbit of a planet is a circle, what can you say about its distance from the sun?
2. Now place the paper on the piece of cardboard. Tie the two ends of your string together. Push the 2 tacks firmly into your unlined paper, 2 inches apart. Loop the string around the tacks. Insert a pencil in the loop and pull the string very tight with the pencil. Move the pencil carefully, keeping the string tight at all times, and the pencil will trace an ellipse.



Remove one tack and label this point *S*. It is called focus (plural: foci). Draw lines in various directions from point *S* to the edge of the ellipse.

a. How many foci do we find in our ellipse?

b. What can you say about distances from a focus to the edge of the ellipse?

c. Compare radii of circles to lines drawn from the focus of the ellipse.

Conclusion

1. What is the shape of the orbital path of Earth and other members of the solar system?
2. Where is the sun in relation to the elliptical orbits of the planets?
3. If Earth travels in an elliptical orbit around the sun, what can we conclude about its distances from the sun at various times during its period of motion (revolution)?
4. When Earth is closest to the sun, we say that the Earth is at *perihelion;* when Earth is at its greatest distance, it is at *aphelion.* Using the chart on the board, on what date would Earth be at perihelion? aphelion?
5. *How would the shape of the ellipse change if the thumbtacks are moved further apart? (Do this to find out.)*
6. *What shape would the ellipse take as the foci are moved closer together? (Do this to find out.)*

Homework

1. All charts describing planetary distances use the term *average* distance. What does this tell us about the shape of the orbits of planets?
2. Why is it true to say that Mars has a perihelion and aphelion?
3. The moon's orbit around Earth is an ellipse. What is the best time to bounce radio waves from the moon? Why?
4. *Why are some spring tides higher than others?*

15. HOW DOES THE CHANGE OF ENERGY EXPLAIN THE ORBITS OF THE PLANETS?

Outcomes

- The movement of the planets indicates that the solar system possesses kinetic energy.

- Planets closer to the sun will move faster than those further away.
- A planet, travelling in its elliptical orbit around the sun, will move faster when closer to the sun.

Motivation

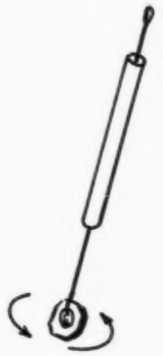
Show with the Tripansee Planetarium, the motions of the Earth. Elicit from the class that these motions are revolution and rotation. Ask, "Why is the Tripansee Planetarium incorrect with respect to the Earth's orbit?" (Earth in this model follows a circular path.)

Development

1. Review the facts that all the planets move in elliptical orbits around the sun and that the sun is at one focus of this ellipse. By use of a diagram, point out that the Earth is closer to the sun in winter (perihelion) and farther away in summer (aphelion).
2. By means of the following demonstration, elicit from the class that the closer a planet is to the sun, the faster it will revolve:

   Pass a 2-foot length of strong cord through a 1-foot length of heavy glass tubing. (Tape tube as a safety precaution.) Tie a weight to one end, and make a loop on the other. Hold the tube vertically in your right hand. Hold the cord with the left hand. Rotate the tube in a narrow circle so that the weight begins to revolve in a wide circle. When the weight is revolving steadily, stop swinging and shorten the cord by pulling some cord up through the tube. The class will observe that the weight revolves through a smaller circle, but more rapidly.

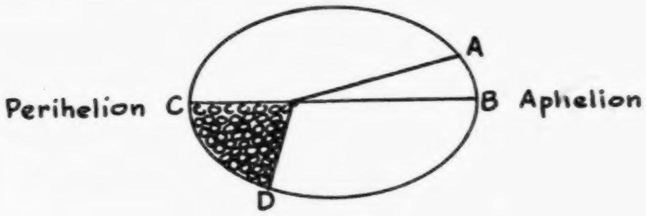
   Point out that the astronomer Johannes Kepler observed a similar condition in our solar system. Planets move faster in their orbits when they are closer to the sun.



3. Review the 8th grade unit on kinetic and potential energy. Use a paddle with a rubber band connected to a ball to illustrate this.

(When you hit the ball, the kinetic energy of the speeding ball changes into potential energy within the rubber band. As the ball returns, it speeds up, transferring the potential energy of the rubber band into kinetic energy.) Point out that in planetary motion the gravitational attraction of the sun on the Earth can be compared with the rubber band and the ball. As the Earth approaches aphelion, it will slow down, losing kinetic energy and gaining potential energy. The opposite takes place as the Earth approaches perihelion. This explains why the Earth, in its orbit around the sun, moves faster when it is closer to the sun (perihelion) and slower when it is farther from the sun (aphelion).

4. *Use a transparency to show that a planet's radius vector sweeps through equal areas in equal time. Draw an ellipse. Produce a segment at perihelion by drawing 2 radii from the sun (focus) to the edge of the ellipse. Fill this segment with some small objects of uniform size (marbles, coins, etc.). Then draw another radius from the sun and extend it to the aphelion edge. Place the same amount of objects along this radius and draw another radius to enclose this segment. Ask class to compare the areas. Ask class to note the length of each arc, (A to B) (C to D).*



They will note that:

a. The areas are approximately equal and that arc C-D is longer than arc A-B.

b. Since the time the planet moves through both arcs is equal, the planet will move faster through C-D as compared to A-B.

Summary

1. Is Earth's velocity constant as it travels in orbit around the sun?
2. When does the Earth move fastest in its orbit? Slowest?
3. As the Earth comes closer to the sun, what happens to gravitational attraction between the sun and the Earth?

4. At perihelion, what keeps the Earth from being pulled into the sun?
5. *How does the fact that radii sweep through equal areas in equal periods of time prove that a planet travels fastest at perihelion and slowest at aphelion?*

Homework

1. Mercury is closer to the sun than Venus. What can you say about the speed of Mercury in orbit as compared to the speed of Venus?
2. At which point of its orbit (perihelion/aphelion) is the potential energy of a planet greatest, with respect to the sun.
3. *At which point in the orbit of a planet (perihelion or aphelion) does the planet expend the greatest amount of kinetic energy?*
4. *What was Johannes Kepler's major contribution to an understanding of planetary motion?*

Materials

Tripansee Planetarium
Strong cord (2 ft.)
Glass tubing (1 ft.)
Weight
Small marbles or coins
Paddle connected to rubber ball with rubber band
Transparency
Tape
Small marbles or coins

◆

REVIEW AND REINFORCEMENT (10-15)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Topics for Reports

1. Brahe Kepler
2. Newton
3. Bay of Fundy
4. Orbital Velocity

PRINCIPAL ELEMENTS: SOLAR SYSTEM

Planet	Average Distance from Sun in		Average Diameter Miles	Period of		Inclination of Equator to Orbit	Number of Satellites	Orbital Velocity Mi/Sec	Surface Gravity (Earth = 1.)
	Miles	A.U.		Rotation	Revolution				
Mercury	36,000,000	.387	3,100	58.65d	88d	?	0	29.7	.36
Venus	67,000,000	.723	7,700	244d ?	224.7d	10°	0	21.1	.87
Earth	93,000,000	1.000	7,927	23h 56m	365.26d	23.4°	1	18.5	1.00
Mars	141,000,000	1.524	4,200	24h 37m	687d	24°	2	15.0	.38
Jupiter	483,000,000	5.203	88,700	9h 50m	11.86 yr	3.1°	12	8.5	2.64
Saturn	886,000,000	9.539	75,100	10h 14m	29.46 yr	26.7°	9	6.0	1.13
Uranus	1,782,000,000	19.182	29,200	10h 49m	84.01 yr	97.9°	5	4.2	1.07
Neptune	2,792,000,000	30.058	27,700	15h	164.8 yr	28.8°	2	3.4	1.41
Pluto	3,664,000,000	39.439	3,500?	6.387d ?	247.7 yr	?	?	3.0	.3 ?
Sun	—	—	864,000	25.35d	—	—	—	—	27.9
Moon	—	—	2,160	27d 7h	—	6.7°	—	—	.16

This chart may be duplicated for distribution to pupils.

Quiz

Are the following statements true or false? If true, write *true* for your answer; if false, write the word or phrase that should be substituted for the *italicized* word or phrase to make the statement correct.

1. *Spring* tides occur during the first and third quarters of the moon.
2. *Neap* tides have the greatest tidal range.
3. A very high tide *always* occurs during a lunar eclipse.
4. Along coasts the tidal range is *greater than* in midocean.
5. The tides change about *two* times a day.
6. The direct high tide is due chiefly to the gravitational attraction of the *sun.*
7. The incoming tide is known as the *ebb* tide.
8. *Inertia* explains why a rocket ship can continue traveling in space after its engines are shut off.
9. *Gravity* keeps the moon from moving away from the Earth.
10. The planets travel in a *circular* orbit around the sun.
11. *Perihelion* is the planet's closest distance from the sun.
12. Orbital velocity changes with *altitude.*
13. You fall *forward* when a bus starts.
14. You fall *forward* when a bus stops.

Topics for Discussion

1. What Life Would Be Like on the Planets (gravity, atmosphere, etc.).
2. Description of Planets
3. Motions of the Planets
4. Possibility of Life on Mars (*National Geographic,* Dec. 1967)

Films and Filmstrips

The following are available from the BAVI Loan Collection.

Sun's Family. 9 min. McGraw-Hill, 1959.

Depicts solar system: the sun and planets that travel about it.

Force of Gravity. (Planet Earth Series). 27 min. Color, McGraw-Hill.

Examines the nature of gravitation from early times to the present.

Elliptic Orbits. 19 min. MTA.

Using Kepler's Law of Areas, film explains effect of gravitational force on satellite.

The following may be purchased. They are from the list of approved audio-visual materials prepared by BAVI.

Gravity, the Mighty Pull. (Film) Item 260.761. 13 min. Color.

Explains gravity and how it affects our lives; includes experiments on weightlessness.

Our Solar System. (Filmstrip) Item 39947.12. S.V.E.

A description of the members of the solar system.

Earth Satellite. (Filmstrip) Item 36905.

How man-made satellites are built and put into orbit; discusses what information they will give us.

Space Stations. (Filmstrip) Item 39552.15.

Discusses basic principles governing the movement of satellites in space and how they are put into orbit. Describes elliptical orbits, changing orbits, orbital decay, and other concepts.

Laws of Motion. (Filmstrip) Item 343.7. E.B.F.

Newton's Laws of Motion and events leading to their discovery.

Laws of Motion. (Filmstrip) Item 38593.35. Popular Science Pub.

Newton's Laws of Motion demonstrated and explained.

Gravity: The Big Pull. (Filmstrip and record) Item 38020.12.

Questions and answers are used in presenting a study of gravity.

◆

16. WHAT EVIDENCES CAN BE OFFERED TO SUPPORT THE FACT THAT THE EARTH ROTATES?

Outcomes

- The turning of the Earth on its axis is called rotation.
- Rotation causes the following:
  - Day and night
  - Deflection of winds and currents
  - Apparent motion of celestial bodies
  - Oblateness of the Earth's shape
  - Change in apparent paths of artificial satellites

Motivation

Ask, "How do day and night prove the Earth's rotation?" Point out that the ancient people believed that the sun was moving, and not the Earth. Indicate that we need other evidence to prove the Earth is rotating.

Development

1. Establish that the Earth's axis points to the North Star. Show pictures of star trails and discuss how they were taken. Ask, "How can these pictures be used as a proof of the Earth's rotation?"

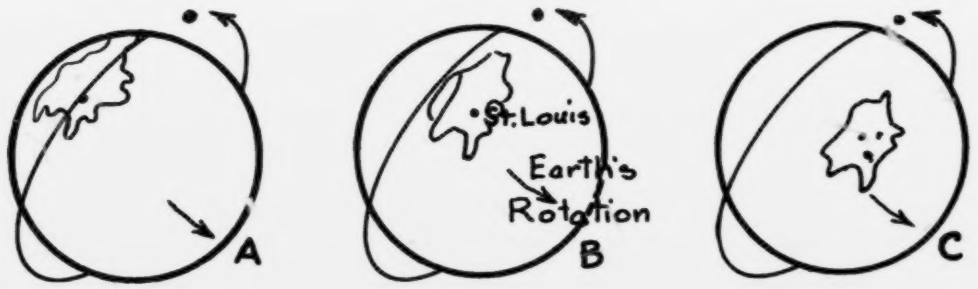
   NOTE: Circular lines of light formed while camera shutter was open indicates movement of either the stars or Earth.

2. Show class a globe of the Earth. Point out that by careful measurements, scientists have determined that the diameter of the Earth through the equator is 27 miles more than through the poles. This causes a *slight* bulging at the equator. Demonstrate this oblate spheroid by whirling two flexible steel hoops set at 90° to each other on a hand-operated rotor. Have students relate the flattening of the hoops to the flattening of the Earth's poles, both being caused by rotation. (The Earth's mass is thrown outward from the axis by the forces of rotation.)

3. Demonstrate the Coriolis effect by using a slate globe that rotates easily. Hold the axis vertically and pour a small amount of water on the north pole of the stationary globe. Repeat the demonstration

with the Earth rotating from west to east. Have students note the deflection of the water. Recall from the 8th grade unit on weather that winds (which behave in a similar fashion to water) are deflected in the same directions due to the Earth's rotation.

4. Pose the following problem to the class. An artificial satellite is launched into a polar orbit as shown in the following diagram. Draw or project a transparency of this diagram.



Elicit that the orbits of satellites remain unchanged for a long period of time due to the inertia of this moving body. Mention that scientists have confirmed this with accurate tracking and measurements of existing satellites in orbit. Point out that the satellite orbits the Earth in 2 hours and is over a different location with each orbit. Ask, "How is this a proof of the Earth's rotation?"

5. *Show a model of Foucault's Pendulum. Elicit that the weight swings in the same plane due to its inertia. Ask the class how this proves the Earth's rotation. Point out that a large pendulum, demonstrating the Earth's rotation, is kept swinging in the United Nations building.*

6. *(Optional)*
Demonstrate the proof of the Earth's rotation by means of the Foucault's Pendulum experiment. Hang a heavy metal weight (1,000 gms) from a long thin strong wire attached close to the ceiling. The pendulum can be observed to swing in its original path (use a chalk mark) while the room turns because of the Earth's rotation (some movement can be noted after one hour).

Summary

1. Why did the ancient people think the Earth was stationary?

2. What proofs are there that the Earth is rotating?
3. How does the spinning of the Earth affect its shape?
4. *Why can't you feel the motion of the rotating Earth?*
5. *If you were at the North Pole and a large Foucault Pendulum was swinging overhead, how would it appear to you?*

Homework

1. What is the most modern proof of the Earth's rotation?
2. How does the Coriolis force explain the Earth's rotation?
3. *Why is Foucault's experiment a good proof of the Earth's rotation?*
4. *Take photos of star trails. Which star is at the center of the star trails?*

Materials

Pictures of star trails
Globe of Earth
2 flexible steel hoops

Hand rotor
Slate globe
Model of Foucault's Pendulum

17. WHAT CAUSES SEASONS?

Outcomes

- The Earth's axis is inclined at an angle which constantly points in one direction.
- The revolution of the Earth and the tilt of the Earth's axis cause seasons.
- The more vertical the rays of sunlight that strike the Earth, the more heat the Earth receives.
- *Length of day will vary with the seasons.*

Motivation

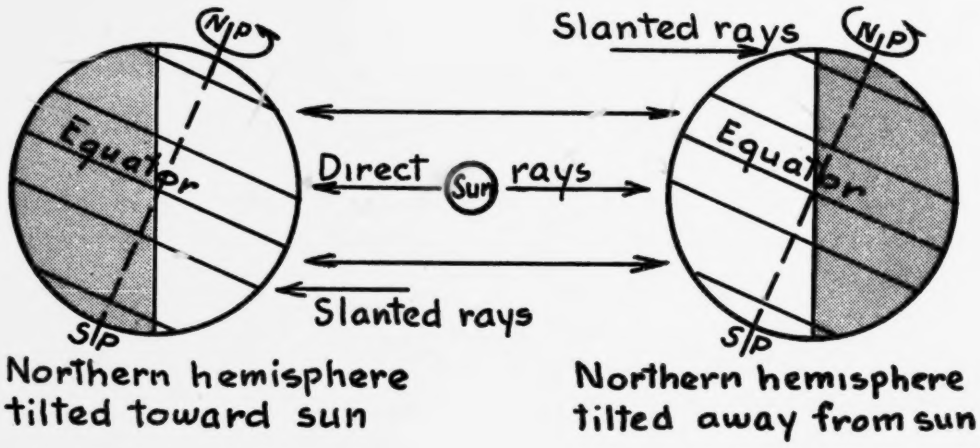
Ask the students to choose the best time of the year to have an outdoor swimming party and an outdoor ice skating party. Elicit from them as exact a date as possible and ask why these dates were chosen.

Development

1. Demonstrate revolution with the Tripansee Planetarium. The model will show that the Earth's axis is inclined. Have class note that the axis always points in the same direction (toward the North Star).

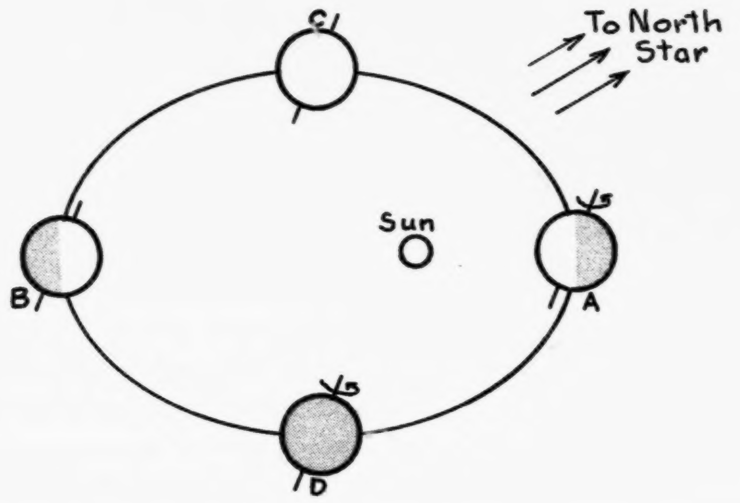
2. Demonstrate that direct rays are more intense than slanted rays by shining the beam of a flashlight or slide projector directly on a piece of cardboard. Then tilt the cardboard away from the light. Ask class to compare the areas covered by the light in each case and the intensity of the light in each case.

3. Ask, "Where will the Northern Hemisphere receive more direct rays?" By means of a transparency or large diagram, show that when the Northern Hemisphere tilts toward the sun, it will receive more direct rays than when it slants away from the sun.


N/P
Slanted rays
N/P
Equator
Direct
Sun
rays
Equator
Slanted rays
S/P
S/P
Northern hemisphere tilted toward sun
Northern hemisphere tilted away from sun

Elicit from the class that the more direct rays will produce more heat. Ask, "What time of the year will it be in the Northern Hemisphere when we receive the more direct rays?"

4. With the aid of the Tripansee Planetarium, show that the Northern Hemisphere will change its position (tilt toward or away from the sun) as the Earth revolves around the sun. Reinforce this with a diagram or transparency.



Elicit that at point *A* the Northern Hemisphere is slanted away from the sun, thus receiving slanted rays. In position *B* it is slanted toward the sun, thus receiving more direct rays. Point out that at positions *C* and *D* the Northern Hemisphere is neither pointing toward nor away from the sun so that the angle of the sun's rays will be equal in either hemisphere.

Have the class fill in the time of the year in the Northern Hemisphere. (A-winter, B-summer, C-spring, D-fall.)

5. *Using the diagram showing the angle of the sun's rays, discuss the length of day when the Earth is at various positions and what effect this would have on the seasons. Explain terms such as solstice (sol-sun, stice-standing still) and equinox (equi-equal nox-night) and the dates of their occurrence.*
6. *Point out that Earth is closer to the sun in the winter (91½ million miles) than in the summer (94½ million miles). Elicit that distance appears to have nothing to do with the seasons.*

Summary

1. Describe the position of the Earth's axis in summer and winter.
2. Why is sunlight more concentrated in summer than in winter?
3. How does this affect the Earth?
4. *Explain why summer days are longer than winter days.*
5. *Why doesn't the Earth's change in distance affect our climate?*

Homework

1. Explain why the Northern Hemisphere's summer is the Southern Hemisphere's winter.
2. Why can you get a more severe sunburn in summer than in winter even though you sit in the sun for the same period of time?
3. List the two causes of seasons.
4. Why could we call noontime the summer of the day?
5. *When does each of the following take place: the summer and winter solstices and the equinoxes?*
6. *Why is the Arctic region called the "land of the midnight sun?"*

Materials

Tripansee Planetarium
Transparency or chart
Flashlight or slide projector
Cardboard

18. WHAT CHANGES ARE OBSERVED ON THE EARTH AS A RESULT OF THE EARTH'S MOVEMENTS?

LABORATORY LESSON

Outcomes

- The movements of the solar system are used to measure time.
- One full rotation of the Earth represents a day.
- A year is based upon the revolution of the Earth around the sun.
- A sundial is an instrument which may be used to determine the time of day by measurement of the sun's shadow.

Motivation

Ask 5 or 6 students to stand or sit quietly in front of the room. Tell them to close their eyes and raise their hands at the end of one minute. Have the rest of the class check to see how well they estimate time.

Development

1. Have students realize the need for more accurate methods of keeping time. Elicit ways of estimating time (pulse or respiration rate or counting "one one thousand," "two one thousand," etc.)
2. Ask a pupil to write his date of birth on the board. Elicit the various units of time.
3. Distribute materials to each group of pupils. Guide them in performing the laboratory activity.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 18

Problem: How can we measure time?

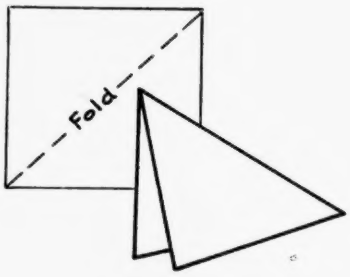
Materials

- Watch or clock with sweep second hand
- Calendar showing phases of the moon
- Flashlight
- Metronome
- 2" x 2" sheet of paper
- Candle (birthday)

Procedure and Observations

1. Notch the birthday candle into 4 equal parts by scratching it with your pencil or nail. Light the candle and check how long it takes to burn down to the first notch.
   a. If the second notch extends down the candle the same distance as the first, how long will it take to burn down to the second notch?
   See if this is true.
   b. How long will it take for the candle to burn out?
   c. Why is this a better method of determining periods of time than counting or estimating?
2. Take your square paper and fold it in half. Then open it up so that one end will stand upright.

   Shine your flashlight on the folded square so that the upright piece of paper (pointer) will cast a shadow.



Start to the left of the pointer and slowly move the flashlight to the right.

- a. What happens to the length of the shadow?
- b. When do you get the shortest shadow?
- c. If you set this up outside on a sunny day, at what time of day would you get the shortest shadow?

3. Check through your calendar and count how many days occur between each phase of the moon.
   - a. How could we use this as a method of telling time?
   - b. What measurement of time could you possibly use for the interval of time between quarter moons?
4. The sun is lower during the day in winter (days are shorter); in summer the sun is higher in the sky (days are longer).
   - a. How will the position of the sun in the sky affect the shadow cast at noon in summer and in winter?
   - b. How could the position of sun in the sky be used to indicate the time of the year?

Conclusion

1. Make a list of the various ways people kept track of time before the mechanical clock was invented.
2. Make a list of the various units of time.
3. Next to each unit of time listed in question #2, place the Earth's motion that each depends on.

   NOTE: Some of the time measurements listed may be man-made.
4. What is the period of time from one full moon to the next full moon?

Homework

1. How were the months named?
2. How did the days of the week get their names?
3. See if you can list the names of the days of the week in another language (Spanish, German, French, etc.). Compare them with our names for the days of the week.
4. *Explain how you could use the motion of the stars to tell time.*
5. *Why doesn't a sundial time coincide with your wristwatch time?*

19. WHAT MAKES A ROCKET MOVE?

Outcomes

- The rocket engine is an application of the Law of Action and Reaction.
- Only rocket engines are designed to work in space.
- A rocket carries its own supply of oxygen and is independent of the Earth's atmosphere.

Motivation

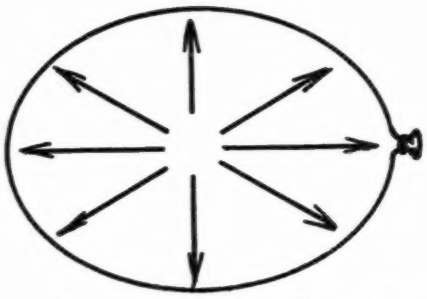
Ask a pupil to bring in roller skates and put them on. Tell him to throw a basketball to you. Students will note that he moves in an opposite direction to that of the ball. Repeat, each time throwing the ball a little harder.

Development

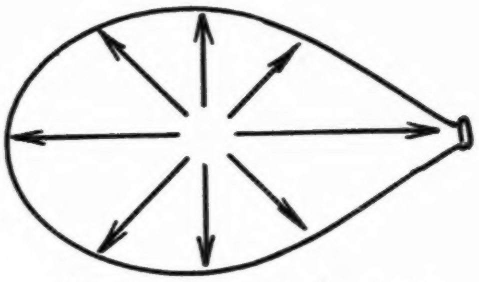
1. Point out that the preceding demonstration is an example of Sir Isaac Newton's third law of motion: For every action there is an equal and opposite reaction. Elicit other pupil experiences which demonstrate the same principle such as jumping off a rowboat, hitting a baseball, kicking open a door, and riding in a bus or subway.

2. *Ask, "What enables you to jump upward?" Have students realize that they push downward on the Earth with a force that exceeds their weight. The equal and opposite force the Earth exerts causes the person to lift off the ground.*

3. Blow up a balloon. By means of a diagram show that the compressed air pushes in all directions against the inside walls of the balloon. Release the balloon, letting air rush out. The balloon then speeds off. Elicit that the balloon moves forward because the escaping gases cause an unbalanced force in the balloon. The greater force in the balloon, opposite the opening, pushes the balloon forward. The result is a movement of the balloon (reaction) in an opposite direction to that of the escaping gases (action).



Balanced forces



Unbalanced forces

Elicit that the outside air has nothing to do with the motion and that the balloon would move faster in a vacuum such as "space."

4. Using appropriate filmstrips, transparencies or pupil-made models, compare jet engines to rocket engines. Explain briefly how each engine works. Elicit that both develop thrust as an application of the action-reaction law. Ask why even the most powerful jet airplanes could never fly to the moon. Lead the pupils to suggest that any aircraft, such as a rocket, that works in an airless space has to carry its own oxygen to burn its fuel.

5. *Discuss the various types of rocket fuels that are presently being used (solid and liquid propellants). Lead students to suggest other types of fuels that will be used in the future (ion propulsion).*

Summary

1. Explain how the firing of a rifle demonstrates the Law of Action and Reaction.
2. Why would a deflating balloon travel farther in a vacuum?
3. Why are rockets used for space travel?
4. *What are the advantages and disadvantages of solid and liquid fueled rockets?*

Homework

1. Why does a rocket engine work better in a vacuum than in the air?
2. Name three things that illustrate the Law of Action and Reaction.
3. *Discuss various ways that would enable a rocket in space to move in different directions.*

4. *What is thrust? What methods are used to increase the thrust of a rocket?*

Materials

Skates	Basketball	Balloons

20. HOW WILL WE OVERCOME THE FORCES OF GRAVITY IN OUR SPACE INVESTIGATIONS?

Outcomes

- Gravity is a force which pulls objects to Earth.
- For space exploration, energy must be supplied to develop a force sufficient to overcome gravity.
- To overcome the pull of gravity on Earth, a rocket must attain a thrust of 25,000 mph (escape velocity).
- A multistage rocket can attain escape velocity.

Motivation

Ask if pupils ever heard the statement, "Everything that goes up must come down." Ask if the statement is true.

Development

1. Throw a ball. Elicit why objects fall back to Earth.
2. Demonstrate, by shooting a piece of paper into the air with a rubber band, that the more force you apply, the higher the paper will go. (More potential energy will be changed to kinetic energy.) Point out that anytime you do this the paper comes back down. Ask, "What must be done so that the paper will not fall to the ground?" Tell the class that the force needed to overcome the force of gravity on the earth is one which tends to move an object at a speed of 25,000 mph and is called "escape velocity."
3. Point out that the gravitational force decreases with distance (Lesson 12). This explained why the moon, which was closer, ex-

erted a greater gravitational attraction than the sun. Ask, "At which point in a space launch do you need your greatest thrust?"

4. Discuss how a multistage rocket can supply the greatest amount of thrust when needed and how it is possible to eliminate the excess mass by dropping off separate stages during the flight.

5. *State Newton's Laws of Motion (Inertia, Momentum, and Action-Reaction). Discuss how these have made space trips possible.*

6. *To illustrate the phenomenon of weightlessness in a space capsule in orbit, hold a spring scale and have a student pull it. Let him stop when the balance reads 50 grams. Ask class what force was applied to the scale. Have the student exert the same force a second time, but this time offer no resistance to the pull and let him move his hand while you move yours along with him. Point out that even though he is trying to exert a force, the scale is moving with him and the scale reads zero. Point out that the astronaut is "moving or falling" with the ship and this is what produces the phenomenon of weightlessness.*

Summary

1. Explain, in terms of gravity, why it is easier to lift a light object than a heavy one.
2. Define "thrust."
3. What is "escape velocity"?
4. Why is the escape velocity on the moon less than that on the Earth?
5. What are the 2 factors that determine the speed of the rocket?
6. *State Newton's three Laws of Motion and apply them to a launching and orbiting of a space vehicle.*

Homework

1. Explain why you do not weigh the same on all planets.
2. How is escape velocity related to weight?
3. List several methods that can be used on Earth to obtain escape velocity.

4. *An astronaut is floating outside his spaceship and finds he can't get back in. He reaches for the fire extinguisher at his side. Explain how he will be able to get back into his ship.*

Materials

Balls of various sizes
and weights

Rubber band
Spring scale

◆

REVIEW AND REINFORCEMENT (16-20)

Note: The instructor may select the most suitable of the following suggestions for review and reinforcement.

Matching

1. Proof of Earth's rotation
2. Point nearest the sun
3. Movement of Earth on its axis
4. Revolution and tilt
5. Tendency to remain in motion
6. Overcome planets' gravitational pull
7. Solar timepiece
8. A rocket's speed
9. Alcohol and oxygen
10. "Summer of the day"

a. causes seasons
b. escape velocity
c. thrust
d. star trails
e. noontime
f. rocket fuel
g. perihelion
h. causes day and night
i. inertia
j. sun dial

Topics for Reports

1. Newton
2. Foucault
3. Goddard
4. Benjamin Banneher
5. Space Projects (Lunik, Mariner, etc.), NASA

6. "g" Forces
7. Clocks and Calendars
8. Rockets and Rocket Fuels
9. Time Zones and International Dateline

Projects

1. Construction of a sundial as illustrated in *Time in the Stars* by Joseph M. Chamberlain. (Natural History Press, N.Y., 1964. Available from Hayden Planetarium. 50¢)
2. Construction of Foucault Pendulum.
3. Toy construction, using action-reaction devices to propel them.
4. Construction of lunar calendar for a year.

Films and Filmstrips

The following films are available on loan from the BAVI film collection.

Gravity, Weight and Weightlessness. 11 min. Film Assoc. of Calif.

Relationship between weight and gravity.

Jet Propulsion. 14 min. E.B.F. 1953.

Explain workings of jet engines and the principle of physics on which they are based, with special emphasis on Newton's third law of motion.

How Do We Know the Earth Moves? 11 min. FAC.

Illustrates reasoning by which scientists have established the facts that the Earth rotates on its axis and revolves around the sun.

Man in Space. 27 min. Color. Disney Films, 1957.

History and development of rockets and their application to space travel. A description of weightlessness is included.

The following may be purchased. They are from the list of approved audio-visual materials prepared by BAVI.

Causes of the Seasons. (Film) Item 109.58. 11 min. Coronet.

Tilt of the Earth's axis and its rotation and revolution about the sun are related to seasonal changes.

Space Rockets. (Filmstrip) Item 39552.13. J. Handy.

Principles of rock propulsion, differences between solid and liquid propellants, and the solution to overcoming Earth's gravity.

Motions of the Earth in Space. (Filmstrip) Item 39680.11. McGraw-Hill.

History of various theories of the origin of solar systems; the proofs of the various motions of the Earth.

How Man Explores Space. (Filmstrip) Item 39947. S.V.E.

How 25,000 mph speed overcomes gravity; rockets and rocket stages; essentials of a space capsule.

Our Earth in Motion. (Filmstrip) Item 39340.11. J. Handy.

Rotation, revolution; Earth likened to a gyroscope top.

◆

MAN AND SPACE

Suggested Lessons and Procedures

21. WHAT DANGERS WILL MAN ENCOUNTER ON A TRIP THROUGH SPACE?

Outcomes

- Man must be protected in space from:
  - Harmful radiations
  - Extremes in temperatures
  - Lack of air pressure

Motivation

Use a Geiger counter to demonstrate the effectiveness of various materials to reduce or stop radioactivity. Place sheets of cardboard, aluminum, and lead on top of a bottle of uranium salts, or some radioactive material (S-I List 14-5348.03 Set of sources).

Development

1. Review facts from the 8th grade unit on weather that Earth is protected from different forms of harmful radiations (ultraviolet cosmic rays) by layers of gas within our atmosphere. Elicit that radioactivity is just one type of radiation, and that most types of radiation can be stopped by various materials. Point out that cosmic rays, which can be heard as background noise on the Geiger counter, can be stopped with a thin shield of lead. (This is used in equipping a spaceship and astronaut.)
2. Prepare two jars as follows. One jar is covered with an inch strip of insulating material (paper, wool, or asbestos) and then cov-

ered with a layer of aluminum foil. The second jar is left uncovered. Cover each with a one-hole stopper and insert thermometer into each stopper. Record the temperature of each. Place the jars an equal distance from a source of heat and record their temperatures after a period of time. Elicit that radiations, such as sunlight, are hazardous to space flight since temperatures can reach intolerable limits. Lead pupils to suggest methods for controlling temperature within a spacecraft or an astronaut's suit (air conditioning, heating units, reflecting and absorbing materials). Display a model of a thermos bottle. Ask how its construction can be utilized in designing a spacecraft.

3. Place a slightly inflated balloon into a bell jar that has been connected to a vacuum pump. Withdraw the air from the bell jar and have students account for the inflating of the balloon. Review the fact that there is little or no atmospheric pressure in space. Lead the students to explain why an artificial atmospheric pressure must be supplied to the astronauts while in space. Point out that under very low pressure a person's blood will boil. Show pictures of advertisements for self-sealing automobile tires. Explain their workings and have students realize that the hazards of a meteoroid causing a hole in a spaceship may be eliminated in a similar way.

4. *Demonstrate how the boiling point of water can be decreased by reducing the air pressure. Boil water in an open Florence flask, and allow it to cool for a minute. With a solid rubber stopper, seal the flask and invert it under running cold water. Elicit that cooling of the air in the flask will cause condensation of the water vapor, lowering the pressure and boiling point of water. Have students relate this to the so-called boiling of a person's blood under very low pressure.*

Summary

1. What types of radiation will man encounter in space? How will this affect the design of spaceships?

2. Why is the astronaut's suit so vital to him when leaving the spaceship?

3. Name 3 ways of controlling temperatures in a spaceship.

4. *How will a decrease of air pressure in a spaceship be prevented when an astronaut leaves it?*

Homework

1. How will rotating a spaceship help to alleviate the temperature problem?
2. What problem arises from the use of lead in a spaceship as a protection against radiation?
3. After blowing up a balloon, break it with a pin. Discuss how this relates to a meteor's striking a spaceship and the possible results.

Materials

Sheet of each: lead, aluminum, cardboard
Bell jar and vacuum pump
2 jars with 1-hole stoppers
Florence flask and stopper
Insulating material
Aluminum foil
Geiger counter
Radioactive source
Heat source
Thermometers
Thermos bottle
Balloon

22. HOW CAN MAN'S NEEDS BE PROVIDED FOR IN SPACE?

Outcomes

- Man must be supplied with adequate food, water, and oxygen in space.
- There must be provision for the elimination of waste materials.
- *Psychological problems of astronauts must be considered.*

Motivation

Close the doors and windows of the classroom. Pretend that the classroom is a spaceship. Ask, "What preparation is necessary to prepare the room for a journey into space?"

Development

1. List pupil's suggestions on the board. These should include shield-

ing from radiation, sealing all leaks to maintain pressure, proper insulation, supplies of food, water, and oxygen.

2. Point out that on a short flight, such as to the moon, most of the food, air, and water can be carried along as done presently by astronauts. Recall that the vast distances to other planets require long confinement. Elicit more appropriate methods to provide for man's needs on voyages that will last for months or years.

3. Place Ludwigia or Elodea (found in any pet shop) under an inverted funnel in a beaker of water. Fill a test tube with water, invert it over the stem of the funnel, and place the entire setup in sunlight. Bubbles will start to displace the water in the test tube within a short time. Elicit the fact that the plant is giving off oxygen. (It may be necessary to wait for the following day to test for oxygen in the test tube.) By means of a diagram, review the process of photosynthesis. Elicit how this process will supply astronauts with oxygen and some food (from the green plants). Point out that large tanks of algae such as Chlorella will be able to serve as an excellent source of oxygen, and because of its rapid reproduction, as a source of food.

4. Lead pupils to suggest other types of food that can be used, such as powdered, condensed, and irradiated foods. Discuss the problem of drinking fluids in state of weightlessness.

5. Elicit the usefulness of various waste products produced by man (CO_2, H_2O, urea, solids). Elicit ways in which these waste products will be continuously changed (recycled) into useful products.
   a. CO_2 will be used by plants.
   b. Algae would make use of important elements in waste products to form essential nutrients.
   c. Distillation, absorption devices, and filtering units will recover water from liquid wastes.

Lead pupils to understand that, in the selection of astronauts, each one is put through a series of psychological tests. Elicit some psychological problems an astronaut may encounter.

a. remaining in closely confined areas for long periods of time

b. loneliness and isolation *c. fear of the unexpected*

Ask for suggestions for eliminating or reducing these problems.

Summary

1. How will plants aboard a spaceship supply food, water, and oxygen?
2. How will the waste products of astronauts be recycled into useful by-products?
3. *What is the advantage of a varied menu for a flight crew?*
4. *Why must the selection of astronauts and passengers for space voyage be highly selective?*

Homework

1. What methods are known for supplying oxygen to the crew of a space flight?
2. Why must man be able to reuse his waste materials during space flights?
3. *What is hydroponics? How can it be used during extended space flights?*
4. *Why is the selection of astronauts based on both physical and mental examinations?*

Materials

Test tube **Beaker** **Funnel** **Plants**

23. HOW DO THE POSITIONS OF STARS HELP MAN TO FIND HIS WAY?

LABORATORY LESSON

Outcomes

- Constellations are groups of stars that appear to form patterns in the sky.
- Constellations enable man to locate stars in the heaven.
- Stars can be used by man to navigate on Earth and in space.

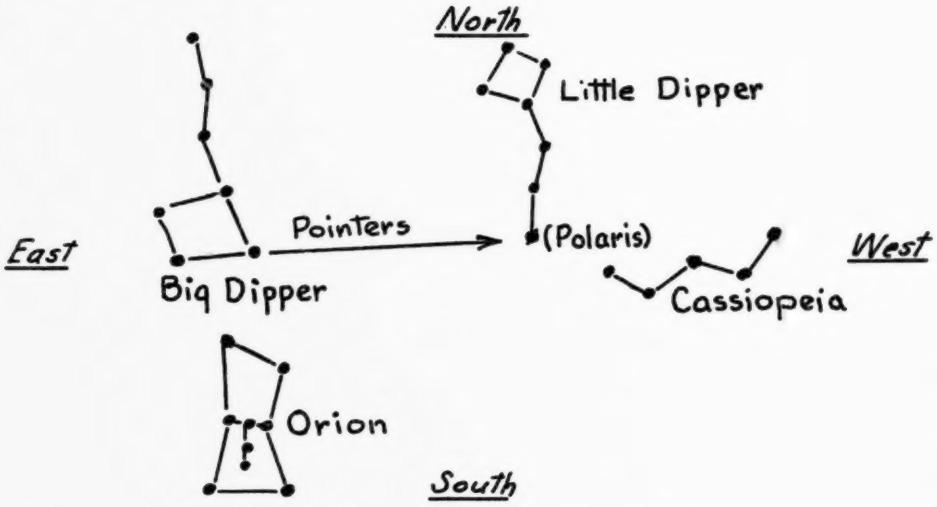
Motivation

Write the following words on the board: Pisces, Aquarius, Capricorn, Sagittarius, Scorpio, Libra, Virgo, Leo, Cancer, Gemini, Taurus, Aries. Ask, "What do these words mean?" Point out that these are the names of various constellations they will study.

Development

1. Project a transparency or chart of the northern sky. Ask the pupils if they recognize any patterns. Point out that groups of stars are called constellations.

2. Show class how the North Star (Polaris) may be located by use of the pointer stars of the Big Dipper (Alpha and Beta — 1st and 2nd brightest stars in the constellation) as shown in the diagram.



Review the fact that the North Star is located almost directly over the North Pole. Ask how this fact could be used in navigation. (North Star indicates the direction north.)

3. Distribute materials to each group of pupils. Guide the pupils in performing the laboratory activity.

   NOTE: Star charts may be obtained from S-I List, or may be duplicated from one published in *Sky and Telescope, Science Newsletter,* or other magazines that deal with astronomy.

   Check to see that the star chart is prepared for the time of year that you will be teaching this topic.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—EARTH SCIENCE: LESSON 23

Problem: How can we locate some well-known stars and constellations in the Northern Hemisphere sky?

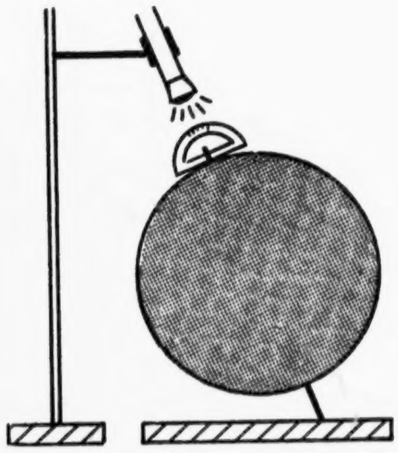
Materials

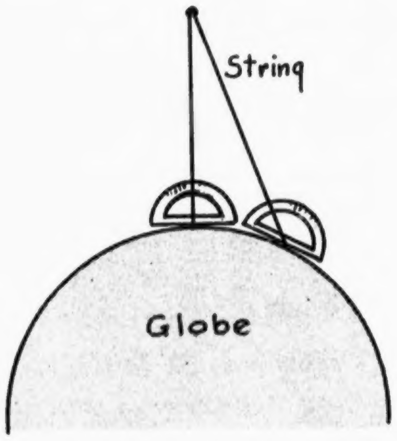
Star chart of Northern Hemisphere (this season)
3 x 5 index cards
Pin
Stand
String
Globe
Protractor
Penlight

Procedure and Observation

1. Attach the flashlight to the stand. Light it. It represents the North Star. Place the flashlight directly over the axis of the globe. Why?
2. Now take your protractor and place it at different positions as shown.

   Take a piece of string and connect the North Star to the point where the protractor touches the globe. Note the angle.
   a. Angle at the top of the globe? ____________
   b. Angle at the point you think New York would be? ____________
   c. Angle further south? (Florida) ____________.
   d. What happens to the angle formed with the North Star as you move toward the equator?
   e. Explain why you can't see the North Star south of the equator.
3. Examine your chart of the northern sky. Notice that groups have been named. Find the group named Ursa Major (Big Dipper). Draw this group of 7 stars on a 3 x 5 index card. Three stars extend as the handle with





four stars forming the bowl. Take your pin and punch holes at the proper places. Hold this up to the light. This is how the stars appear at night.

4. The two stars at the end of the bowl of the Big Dipper are the pointers. Draw a line between the pointers on your star chart and extend it about 5 times its length. This will bring you to the North Star (Polaris). Polaris is the end star in the handle of the Little Dipper. The Little Dipper includes 7 stars. Draw the Little Dipper on the 3 x 5 card and repeat the procedure used for the Big Dipper.

   NOTE: Tonight, try to locate the Big and Little Dipper outside your house. Use the pointer stars to find the North Star.

   a. How does the North Star aid you in finding directions?
   b. In what direction does the front door of your school face?

5. Draw a line from the second star (Mizar, a double star) in the Big Dipper's handle to Polaris, and then an equal distance beyond. You will come to the constellation Cassiopeia which is made up of five stars to form a wide *W* or *M*. Draw this on a 3 x 5 card.

6. Locate Orion on your star chart. It is easily identified by three bright stars in a straight line and two stars coming down from these. These stars are enclosed in a box. Copy Orion on your 3 x 5 card. (If you find the Big Dipper at night, Orion will be behind you.)

   a. If you look toward Orion, in what direction will you face?

Conclusion

1. Why is the North Star called the pole star?
2. List 2 ways the North Star can help you in navigation.
3. How can you locate the North Star?
4. List several other constellations from your chart.

Homework

1. Tonight, try to locate the 4 constellations that you constructed in class.
2. Assign numbers to brightness of the various stars in the constellations you observe (#1 the brightest, or #2 less bright, #3 hardly visible).
3. In what direction does the front of your house face?
4. *A sextant is an instrument used to locate one's position on Earth. Using a protractor and weight and string, construct one. (Hint: #2 of the procedure shows how a sextant works).*

24. HOW ARE LATITUDE AND LONGITUDE DETERMINED?

Outcomes

- Latitude and longitude position a place on the Earth.
- Observations of celestial bodies help to determine latitude and longitude.

Motivation

When a space capsule is returning to Earth, rescue ships are given an exact standby position for the capsule's retrieval. Ask, "How do the rescuers know the capsule's position in the sea, without landmarks or signs?"

Development

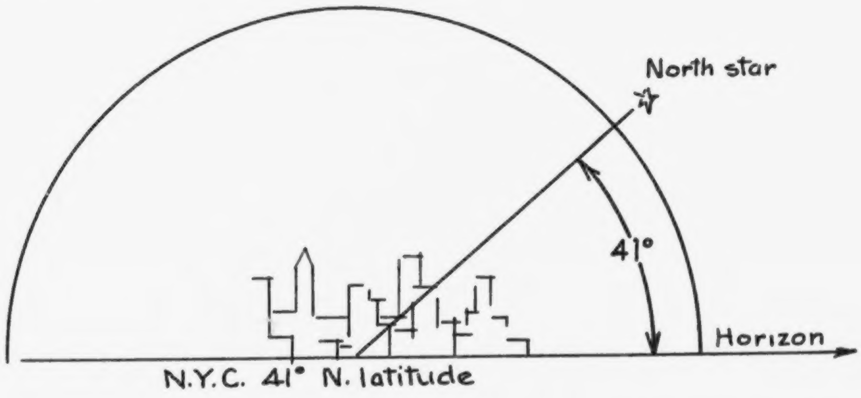
1. Have two students plan to meet in an unfamiliar area in New York City. Lead students to realize they need two reference points, such as 2nd Avenue and 16th Street. Point out that on Earth, man has devised a system of imaginary lines that form a pattern similar to streets and avenues. They are called meridians and parallels. Identify these lines on a large globe and map.

2. By means of a cross-section diagram of the Earth and a globe, point out the Prime Meridian and show how meridians are used to determine *longitude.* Longitude is distance in degrees measured east or west of the Prime Meridian. With the aid of a map, have students determine the longitude of various cities. Elicit the need for another point of reference in order to have enough information to determine an exact position.

3. With the aid of the map and a globe, point out that parallels are used to determine distance in degrees north and south of the equator. This is called *latitude.* Have students practice locating various places on a map, e.g., New York City is 41° north latitude, 74° west longitude. Use cities in foreign countries, too, for drills.

4. Review the position of the North Star as being directly over the North Pole. From the previous laboratory exercise, elicit that it forms a 90° angle. Ask, "What is the latitude of the North Pole?" Point out that in New York City the North Star is located at an angle of 41° above the horizon and that the latitude of New York

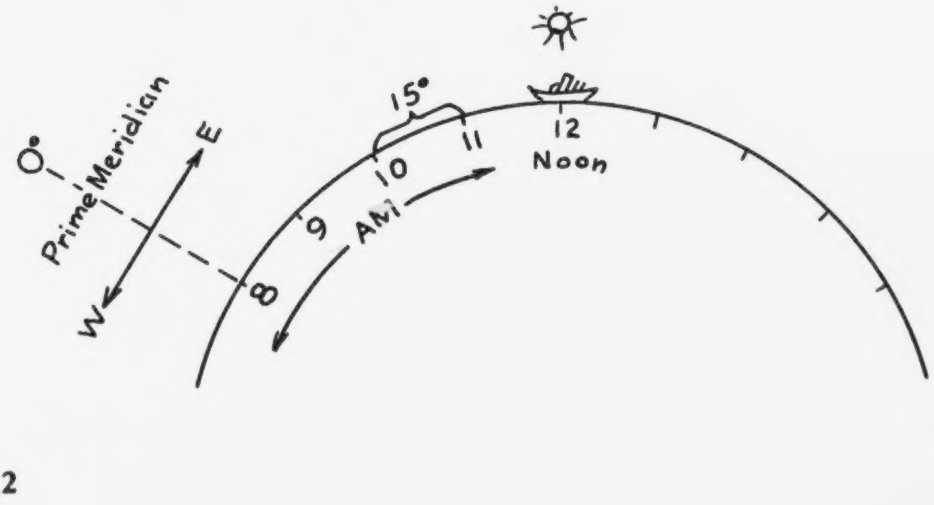
City is 41° north. Develop the relationship of north latitude to the North Star.



5. "How do we tell longitude in the daytime when we do not see the stars?" Review the fact that the Earth rotates 360° degrees in 24 hours. From this, the pupils should be guided to conclude that the Earth rotates 15 degrees per hour and that there exists a difference in time between the Prime Meridian and places east or west of it (one hour for every 15 degrees of longitude). Lead pupils to realize that by comparing the time at Greenwich (0 degrees longitude) to that of your local time, longitude can be calculated. Point out that Greenwich time is obtained by referring to a very accurate clock (chronometer) which is set to Greenwich time.

   NOTE: Greenwich time is also sent over some radio stations.

   A navigator usually checks longitude at 12 noon (when the sun is at its highest point in the sky). For example; at 12 noon, a ship's chronometer shows that the Greenwich time is 8:00 a.m. At what longitude is the boat located? (4 hours × 15° = 60° east long.)



Summary

1. In order to position yourself, why is it necessary to give both latitude and longitude?
2. What is the maximum number of degrees latitude for places on Earth?
3. At 12 noon you observe the sun to be directly overhead. The time in Greenwich is 5:00 p.m. What is your longitude?
4. *How is a sextant used in determining latitude?*

Homework

1. Describe the Prime Meridian.
2. What is a chronometer?
3. By use of a map or globe, give the latitude and longitude of three big cities in the United States.
4. Explain how the North Star is used to determine latitude.
5. Why is longitude on a ship usually determined at local noon?

Materials

Large globe	Large map of Earth

◆

REVIEW AND REINFORCEMENT (21-24)

NOTE: The instructor may select the most suitable of the following suggestions for review and reinforcement.

Quiz

1. Polaris is located in (a) the Little Dipper (b) the Big Dipper (c) Orion (d) Cassiopeia
2. The star located almost directly above our North Pole is (a) Alpha Centauri (b) Betelgeuse (c) Polaris (d) Sirius

3. An example of a constellation is (a) Polaris (b) Orion (c) Aurora Borealis (d) Milky Way

4. The name of star that does not appear to change position during the night is (a) Polaris (b) Sirius (c) Mizar (d) Venus

5. While traveling in space, the space capsule could possibly collide with (a) planets (b) meteors (c) stars (d) other space ships

6. In manned space flights, special provisions must be made to protect the astronauts against (a) heat from friction (b) the cold from outer space (c) radiation (d) all of these

7. Two places on the same meridian must have the same (a) altitude (b) latitude (c) time (d) length of day

8. The maximum number of degrees of latitude on the Earth is (a) 360° (b) 180° (c) 90° (d) 15°

9. In a space capsule of the future, astronauts will give off carbon dioxide which will be used by (a) the engines, as fuel (b) plants (c) small water animals (d) the cooling system of the ship

10. The plants grown aboard the capsule will provide the astronauts with food and (a) carbon dioxide (b) proper temperature (c) oxygen (d) decoration

Suggested Projects

Construction of sextant
Construction of star charts
Construction of compass
Photographs of star trails
Construction of various types of planetariums
Examination of celestial globe

Places to Visit

Hayden Planetarium. New York City
United Nations (Foucault's Pendulum). New York City
Hall of Science. Flushing, New York
Jones Beach. Jones Beach, Long Island
Franklin Institute. Fels Planetarium, Philadelphia, Pennsylvania

Topics for Reports

Modern Methods of Determining Latitude and Longitude
The Constellations: Facts and Fiction
Methods and Instruments Used by Navigators

Films and Filmstrips

The following films are available on loan from the BAVI film collection.

Science in Space (Planet Earth Series). 27 min. McGraw-Hill.

Explains scientific exploration of space. Shows significant discoveries of modern space science, including Van Allen radiation belts.

Latitude and Longitude. 9 min. Color. United World.

Interprets meaning of latitude and longitude. Using a section globe, indicates how a position can be determined.

The following filmstrips may be purchased. They are from the list of approved audio-visual materials prepared by BAVI.

Pictures in the Sky. Item 36245.13, S.V.E.

Describes various constellations in the evening sky and methods of identifying them.

What Is in the Sky. Item 37837.4. Curriculum Materials.

Describes the constellations and planets in the evening sky.

Conditions in Space. Item 39552.1. J. Handy.

Discusses atmospheric pressure, sound, light, and temperatures in terms of outer space. Describes cosmic rays, meteoroids, atomic fragments, and magnetic fields in space.

Man's Preparation for Space Travel. Item 39553.12. J. Handy.

Discusses problems of space travel; pressure, oxygen, gravitational forces, temperature, and a safe return to earth.

◆

UNIT REVIEW: EARTH SCIENCE

Tests

Choice

In front of the numeral, write the letter preceding the word or expression that *best* completes the statement.

_____ 1. The hottest stars are (a) white (b) yellow (c) orange (d) red.

_____ 2. The constellation which helps us locate the North Star is (a) Orion (b) Cassiopeia (c) the Little Dipper (d) the Big Dipper.

_____ 3. Stars appear to make a complete circle around the North Star about every 24 hours because the (a) earth revolves (b) earth rotates (c) stars revolve (d) stars rotate.

_____ 4. A group of stars forming a pattern in the heavens is known as (a) the solar system (b) a constellation (c) meteors (d) comets.

_____ 5. Longitude is always measured from (a) the equator (b) poles (c) Tropic of Cancer (d) Prime Meridian.

_____ 6. An instrument used to analyze the light of stars is a (a) radiometer (b) spectroscope (c) radiotelescope (d) pair of binoculars.

_____ 7. In manned space flights, provisions must be made to protect the crew against (a) heat (b) cold (c) radiation (d) all of these.

_____ 8. A telescope which makes use of a mirror to concentrate light is the (a) reflector (b) refractor (c) radiotelescope (d) spectroscope.

_____ 9. A total eclipse of the moon can occur only at (a) new moon (b) full moon (c) first quarter (d) gibbous.

_____10. Radiant energy from the sun is the result of (a) combustion (b) photosynthesis (c) nuclear fusion (d) uranium.

_____11. The bodies of our solar system revolve around the sun in orbits which are (a) square (b) circular (c) elliptical (d) rounded.

_____12. The time it takes the earth to make a complete revolution around the sun is (a) a day (b) a week (c) a month (d) a year.

_____13. The moon revolves around the earth about once each (a) month (b) day (c) week (d) year.

_____14. Moonlight is caused by (a) burning gases on the moon (b) nuclear energy produced on the moon (c) reflected sunlight (d) the hot surface of the moon.

_____15. You can't see a new moon because (a) it occurs at night (b) it occurs below the horizon (c) the earth's shadow hides it (d) the lighted side of the moon is turned away from the earth.

_____16. The amount of solar radiation received by any part of the earth's surface depends upon (a) its longitude (b) the angle of the sun's rays and the time of exposure (c) the distance from the sun (d) the length of time of exposure.

_____17. The Earth travels (a) faster at aphelion than perihelion (b) faster at perihelion than aphelion (c) at the same speeds at all points of the orbit (d) faster in the summer than in winter.

_____18. The North Pole of the earth's axis (a) always points to Polaris (b) always points to the Big Dipper (c) points to different areas during different seasons (d) always points to the sun.

_____19. The word gravitation (a) is a reference only to the earth's gravitational force (b) refers only to the earth-moon system (c) expresses the universal attraction which all objects have for all other objects (d) refers only to the sun and the planets.

_____20. A rocket engine differs from most engines in that (a) it is more powerful (b) relies on gases thrusting out of its exhaust (c) carries its oxygen along with it (d) depends on water.

_____21. Atmosphere shields a planet from (a) gravity (b) air pressure (c) intense radiation (d) erosion.

_____22. In the sun, one kind of atom is being constantly changed into another kind. These atoms are (a) hydrogen and helium (b) carbon and uranium (c) uranium and hydrogen (d) uranium and helium.

_____23. The eyepiece lens of the optical telescope (a) concentrates light (b) magnifies the image (c) spreads the light out (b) brings the object closer.

_____24. The major cause of tides is the (a) Earth's rotation (b) sun (c) North Star (d) moon.

_____25. The moon appears to rise in the east and set in the west because of the (a) Earth's rotation (b) Earth's revolution (c) moon's rotation (d) moon's revolution.

True or False

If the italicized word makes the statement true, write *True;* if false, write *False.*

1. Tides of greatest range are called *neap* tides.
2. The earth's umbra is shaped like a *cylinder.*
3. Tidal ranges are *greater* along coasts than in mid-ocean.
4. Outgoing tides are called *flood* tides.
5. The *new crescent* phase occurs between full moon and last quarter.
6. Spring tides occur during the *new-moon* phase.
7. Solar eclipses can only occur during the *new-moon* phase.
8. *Potential energy* is stored energy.
9. The moon's shadow is responsible for eclipses of the *earth.*
10. A lunar month is the period of time from new moon to *full moon.*

Completion

Complete the statements.

1. The shape of the moon's orbit is ____________.

2. The moon and sun are on the same side of the earth during ___________ phase.

3. The Earth's revolution and tilt of its axis cause ___________.

4. The Earth, in its orbit, is closest to the sun during the month of ___________.

5. The alternation of day and night is due to the Earth's ___________.

Matching

Match the items in Column A with those in Column B.

COLUMN A	COLUMN B
1. source of all energy on Earth	a) noon time
2. focal length	b) hot luminous gases
3. shortest shadows	c) $E = mc^2$
4. 90° south latitude	d) energy of motion
5. stars	e) developed laws of gravitation
6. spectrum lines	f) identified elements
7. Einstein	g) distance from lens to focus
8. Kepler	h) South Pole
9. Newton	i) sun
10. kinetic energy	j) Law of Planetary Motion

◆

SUGGESTED REFERENCES: EARTH SCIENCE

For the Teacher

Abell, G. *Exploration of the Universe.* New York: Holt, Rinehart & Winston, 1964.

Blanco, V. M. *Basic Physics of the Solar System.* Reading, Mass.: Addison Wesley, 1961.

Boenning, E. M. and Monson, M. *Steps Into Space.* Chicago: Lyons and Carnahan, 1963.

Corliss, W. *Space Probes and Planetary Exploration.* Princeton, N. J.: Van Nostrand, 1965.

Duerocq, A. *Victory Over Space.* Boston: Little, Brown, 1961.

Earth Science Curriculum Project. *Investigating the Earth.* Boston: Houghton Mifflin, 1967.

Flammarion, Camille. *Astronomy.* New York: Scribner, 1964.

Glasstone, S. *Sourcebook on the Space Sciences.* Princeton, N. J.: Van Nostrand, 1965.

Heller, R. L., ed. *Geology and Earth Sciences Sourcebook.* New York: Holt, Rinehart & Winston, 1962.

Hoyle, F. *Astronomy.* New York: Doubleday, 1962.

Muzarka, G. R. *Tools of the Astronomer.* Cambridge, Mass.: Harvard University Press, 1961.

Motz, Lloyd and Duveen, A. *Essentials of Astronomy.* Belmont, Calif.: Wadsworth, 1966.

Strahler, A. *The Earth Sciences.* New York: Harper and Row, 1963.

Trinklein, F. and Huffer, C. *Modern Space Sciences.* New York: Holt, Rinehart & Winston, 1961.

For the Pupil

Alter, P. *Pictorial Astronomy.* New York: Crowell, 1963.

Asimov, I. *The Clock We Live on.* New York: Abelard-Schuman, 1959.

ASIMOV, I. *View From a Height.* New York: Doubleday, 1963.

BERGAMUNI, D. AND EDITORS OF LIFE. *The Universe.* New York: Time, Inc., 1962.

CLARKE, A. *Man and Space.* New York: Time, Inc., 1962.

DULL, C. E., AND OTHERS. *Modern Physics.* New York: Holt, Rinehart & Winston, 1964.

MESSEL, H. AND BUTLER, S. *The Universe and Its Origin.* New York: St. Martin's Press, 1964.

MOORE, P. *Naked Eye Astronomy.* New York: Norton, 1965.

NAMOWITZ, S. *Earth Science, The World We Live in.* Princeton, N. J.: Van Nostrand, 1965.

PICKERING, J. S. *1001 Questions Answered About Astronomy.* New York: Dodd, Mead, 1959.

Sky and Telescope (periodical). Cambridge, Mass.: Sky Publishing Corp.

WHIPPLE, F. *Earth, Moon, and Planets.* Cambridge, Mass.: Harvard University Press, 1963.

Unit IV

BIOLOGY

Asexual Reproduction

Sexual Reproduction

Heredity

ASEXUAL REPRODUCTION
Suggested Lessons and Procedures

1. HOW DO LIVING THINGS CONTINUE TO EXIST?

Outcomes

- The life process of reproduction is essential for the continuation of each type of living thing.
- When living things come from one parent, asexual reproduction has taken place.
- Another method of reproduction among plants and animals is called sexual reproduction.

Motivation

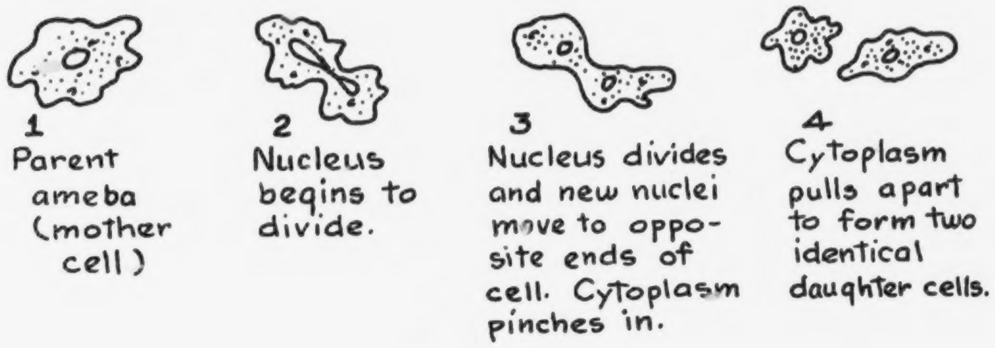
Refer pupils to previous learnings in grade 7 Biology, "The Needs of Living Things." Ask, "How do we know if an object or thing is alive?" Elicit that all living things carry on many basic life processes. Included among these life processes is reproduction. Note that a plant is able to produce more of its own kind. Even though a plant may die in the fall, it leaves many seeds. The following spring, these seeds will produce more plants just like the original plant. Do all organisms reproduce this way?

Development

1. Examples of individual simple organisms reproducing may be shown through the use of charts, prepared slides, filmstrips, or a microprojector. Elicit that in each case only one parent was needed to produce a new individual. Identify this type of reproduction as

asexual reproduction. Note that the new organisms look exactly like the parent.

2. Using the ameba as an example, show the progressive stages through which it carries on reproduction. Direct pupils to make labeled drawings of this process, as shown in this diagram.


1
Parent ameba (mother cell)
2
Nucleus begins to divide.
3
Nucleus divides and new nuclei move to opposite ends of cell. Cytoplasm pinches in.
4
Cytoplasm pulls apart to form two identical daughter cells.

Note: Since pupils have not studied cells since the 7th grade, you may wish to review briefly cell structure and function.

Another example of an organism which undergoes asexual reproduction, in a similar manner to the ameba, is the paramecium. Show prepared slides of paramecia reproducing. How does reproduction in the paramecium differ from reproduction in the ameba? Elicit that in the paramecium there are 2 nuclei which undergo division. Identify this method of reproduction used by paramecium and ameba as binary fission.

4. Discuss means of reproduction among higher organisms. Develop the idea that most cases involve two parents. Elicit that in a litter of kittens there can be a variety of colors present. Further elicit that we do not look exactly like either of our parents. Stress the fact that in these instances, the new individuals show some differences from their parents. Identify this type of reproduction as sexual reproduction.

Summary

1. Why is reproduction important for all species of living things?
2. How is sexual reproduction different from asexual reproduction?
3. *Why is it important for living things to produce their own kind?*

Homework

1. Prepare a chart showing the similarities and differences between sexual and asexual reproduction.
2. *Bacteria also reproduce by binary fission. If a bacterium will undergo binary fission every half hour, how many bacteria would there be after 12 hours? What do you think each of these bacteria will look like?*

Materials

Charts, prepared slides, filmstrips, or super 8 single concept films showing reproduction in simple organisms.

Labeled chart of an ameba.

2. HOW DO CELLS PRODUCE NEW CELLS?

Outcomes

- The cells of all living things are produced by the process of mitosis.
- In mitosis, the nuclear material doubles before the cell splits. When the cell splits, each half will get identical nuclear material.
- Mitosis insures that each daughter cell is exactly like the parent cell.

Motivation

Ask, "How much did you weigh when you were born?" After a number of pupils answer, ask, "What do you weigh now?" Note that their bodies must contain more cells now than at birth. Elicit that some process must be producing new cells. This process is similar to the way one-celled organisms reproduce, studied in previous lesson.

Development

1. Use models, a chart, prepared slides, or a film to illustrate the process of mitosis. Elicit that the nucleus divides and the two new nuclei move to opposite ends of the cell. Then the cytoplasm divides, forming two new cells. Point out that all new cells are formed through this process.

2. Identify the fine threads found in the nucleus as chromosomes. Explain that all the cells of any specific organism contain the same number of chromosomes in their nuclei.

   Present the following list showing the number of chromosomes in various organisms.

Organism	*Number of Chromosomes*
Human	46
Chimpanzee	48
Bullfrog	26
House fly	12
Tomato	24
Rose	14
Corn	20
Black mollies	46

   Does the number of chromosomes in a cell affect the complexity of the organism? Elicit that, in the list above, the chimpanzee has the greatest number of chromosomes but is not the most complex.

3. Ask, "How many chromosomes will each new cell possess after a human cell undergoes mitosis?" Elicit that if there were an equal division of chromosomes, the new cells would each have 23. Elicit what must happen in order to keep the number of chromosomes at 46. (There must be some activity during the mitotic process which doubles the number of chromosomes in the nucleus.)

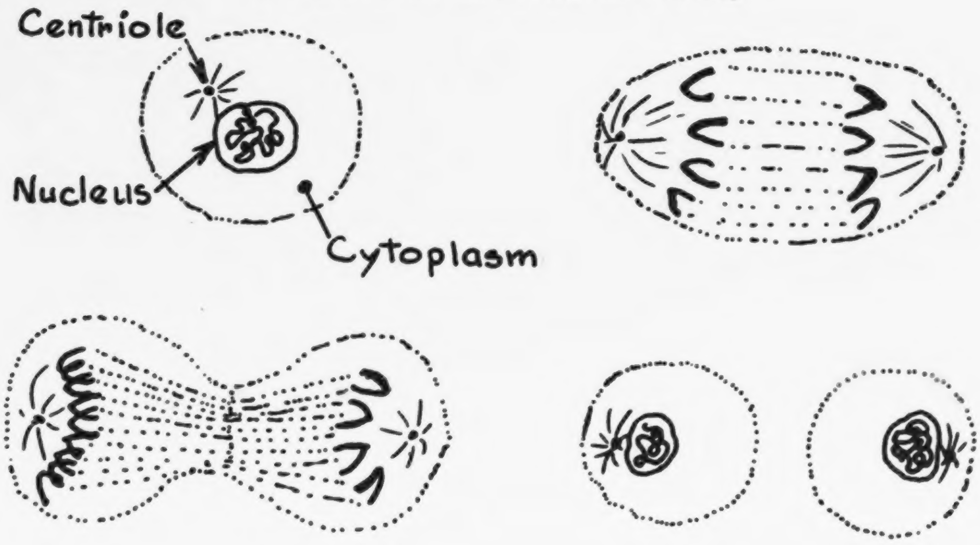
   Demonstrate this process using a 3-inch piece of rubber-coated electrical wire. Point out that during mitosis the chromosomes duplicate themselves to form identical pairs.

   Have a pupil pull the wire apart to separate the duplicate chromosomes. Elicit that the nucleus of each new daughter cell will contain one of these chromosomes. Each daughter cell will contain the same nuclear material. The daughter cells will each have the same number of chromosomes as the parent cell.

4. Refer to the models, chart, prepared slides, or film used at the beginning of the lesson. Have pupils trace the steps which lead to the equal division of nuclear material. Have pupils point out the stage at which the chromosomes split. How many chromosomes are in the parent cell? How many are in each daughter cell?

5. *For some classes, the teacher may wish to detail more of the steps of mitosis. Using a chart (12-1928) and models (12-3948) of mitosis, discuss the stages of mitosis in animal cells. Use as a guide:*
   - *a. the centriole divides and moves to opposite sides of the cell forming a spindle between them;*
   - *b. in the meantime, chromosomes arrange themselves in pairs in the center of the spindle;*
   - *c. one of each of the pairs of chromosomes moves to the opposite side of the cell and the cytoplasm begins to divide;*
   - *d. this continues until two complete cells are formed.*

Mitosis in an Animal Cell



Summary

1. Review the process of mitosis.
2. When an ameba reproduces, why does each daughter cell have the same number of chromosomes as the parent cell?
3. What would happen to the chromosome number if the chromosomes did not divide during mitosis?

Homework

1. Write a description of the process of mitosis.
2. *Investigate the role of DNA in the process of mitosis.*

Materials

Models, a chart, prepared slides or a film illustrating mitosis	3-inch piece of rubber-coated electrical wire

3. BY WHICH ASEXUAL METHODS DO SIMPLE ORGANISMS REPRODUCE?

- The method of asexual reproduction by which an organism divides into 2 identical cells is called binary fission.
- Budding is another method of asexual reproduction in which 2 unequal cells are formed.

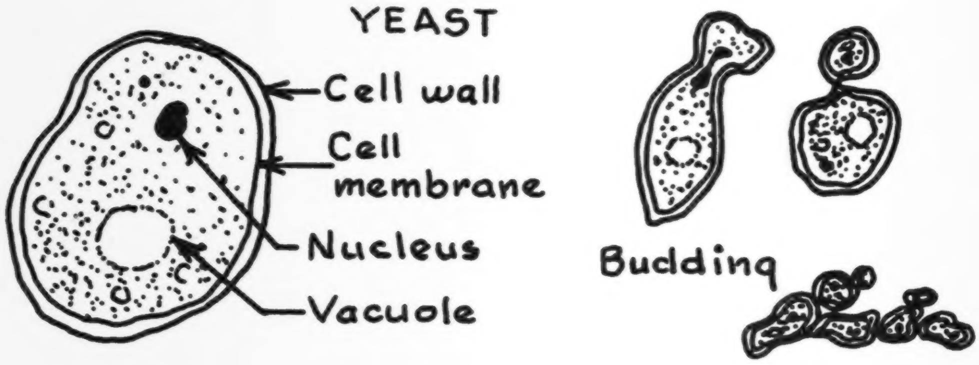
Motivation

Show the class a prepared slide of a yeast culture, using the microprojector. (To prepare the yeast culture, add about ¼ of a yeast cake or ¼ of a package of dried yeast to 100 cc of a 10 percent water solution of molasses, grape juice, or sugar. Let the solution stand in a warm place overnight. One gram of peptone can be added to aid the fermentation process.) Ask the class to try to find yeast cells reproducing. How do yeast cells carry out reproduction? Point out that the new cells being formed are outgrowths of the parent cells. Identify this process as budding.

Development

1. Prepare a stained slide of the yeast culture, using methylene blue stain. Using the microprojector, show the class this slide.
   Have pupils describe what happens during the budding process.
   a. A portion of the cell wall bulges and cytoplasm flows into the space. The bulge is called a bud.
   b. The nucleus moves into the vicinity of the bud and divides into 2 parts.
   c. One of the new nuclei moves into the bud, while the other remains in the parent cell.
   d. The cell wall pinches in, forming a new individual which may remain attached to the parent cell, forming a chain, or may separate from it.

2. Have pupils draw a diagram and label the progressive stages of reproduction in a yeast cell. The following diagram may be used as a guide for the teacher.



3. Have pupils refer to Lesson 1. Identify the process by which ameba reproduce as ***binary fission.*** Some other organisms which reproduce by binary fission are bacteria and paramecia. What are the similarities and differences in reproduction between yeast and the ameba?

YEAST	AMEBA
Daughter cells are different in size.	Daughter cells are the same size.
Unequal division of cytoplasm occurs.	Equal division of cytoplasm occurs.
Cell undergoes mitosis.	Cell undergoes mitosis.

Elicit that cells must undergo mitosis to insure that the chromosomes will not change.

4. *Another type of reproduction carried on by yeast cells is called sporulation. With the aid of a chart or a labeled diagram, demonstrate this process to the class.*

Note that the mother cell nucleus undergoes 2 mitotic divisions, forming 4 daughter cells which remain within the cell wall of the mother cell. Identify each of these four cells as a spore.

Explain that a spore is able to resist drying or other unfavorable conditions. Elicit that yeast cells form spores when conditions are unfavorable. Further elicit that when conditions are favorable each *spore will grow and break out of the original cell wall to repeat the process of reproduction by budding.*

Summary

1. Why is it important for the nucleus to undergo mitotic division during the budding process?
2. Why is budding considered a means of asexual reproduction?
3. *Why are yeast cells able to withstand periods of severe weather?*

Homework

1. Compare the roles of the nuclei in the budding process and in binary fission.
2. Construct clay models showing the steps in the budding process in yeast cells and binary fission in the ameba.
3. *Compare, by means of a chart, the reproductive processes of budding, sporulation, and binary fission.*
4. *Investigate the role of yeast in the process of fermentation. This information should be obtained from reference sources.*

Materials

Yeast culture (See Motivation)

Microprojector

Slides

Methylene blue

4. HOW DOES BREAD MOLD REPRODUCE?

LABORATORY LESSON

Outcomes

- Bread mold is composed of white filaments with small round spore cases at the end.
- Bread mold reproduces asexually through the formation of spores which develop in the spore cases. This method of reproduction is called sporulation.

Development

1. Show several Petri dishes in which bread mold is growing. Ask the class to describe the appearance of the bread mold. Elicit that the bread mold appears to be a white cottony material covered in areas with a layer of black or dark grey.

   NOTE: To prepare cultures of bread mold, place a 2″ square of bread on a piece of moist filter paper in a Petri dish. Spread the bread with dust or let it stand exposed for several hours. The mold will grow best if left in moderate light, at about 30° c, for several days.

2. Explain the method used to prepare the bread mold culture. Ask, "How did bread mold get on the bread?" Elicit that some "seeds" (spores) which must have been present in the dust or air, initiated the growth.

3. Display a chart showing the structure of bread mold (12-2418). Elicit that the cottony material is composed of many fine filaments. The black material, seen on the culture, was composed of tiny black dots at the end of the filaments. Identify these as spore cases. (You may wish to identify the filaments as *hyphae* and the spore cases as *sporangia.*) Further identify this method of asexual reproduction as *sporulation.*

4. Distribute materials to groups of pupils and aid them in carrying out the laboratory investigation.

Summary

Refer to questions on Worksheet to reinforce concepts.

Materials

Bread mold culture in Petri dish	Chart of bread mold (12-2418)

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 4

Problem: How does bread mold reproduce?

Materials

Hand lens
Microscope
Slide
Bread mold culture in Petri dish
Wood splint

Note: Caution the pupils not to taste the mold culture or to inhale any of the particles given off by it.

Procedure and Observations

1. Use the hand lens to examine the mold culture. Do not open the Petri dish. Draw and label a diagram, showing filaments and spore cases, in the space provided.

BREAD MOLD AS SEEN UNDER THE HAND LENS

2. Use a wooden splint to remove several spore cases. Transfer them to a slide and crush them with the wood splint.
3. Place the slide under the low power objective of the microscope. Draw and label a diagram in the space provided, showing spore cases and the spores which were released when the spore cases were crushed.

SPORE CASES AND SPORES AS SEEN UNDER THE MICROSCOPE

Conclusions

1. Bread mold is composed of ______________ with ______________ at the end.
2. "Seeds" produced by bread mold are called ______________.
3. This method of reproduction used by bread mold is called ______________.
4. Sporulation is a form of (sexual, asexual) reproduction.
5. Spores are able to resist extremes in temperature, drying and other unfavorable conditions. How does this insure the survival of bread mold?

Homework

1. Why is sporulation considered to be a form of asexual reproduction?

2. Why do bread manufacturers add mold inhibitors to bread?
3. Why is it that bread exposed to air will become moldy faster than bread in an unopened package?
4. Compare the number of individuals that can be produced by sporulation to the number produced by fission.

◆

REINFORCEMENT AND REVIEW (1-4)

The teacher may select one or more of the following suggestions for review and reinforcement.

Activities

You may wish to have students study mitosis in growing tissues seen on slides such as: onion root tips (12-8398) or whitefish eggs (12-6998). This might be accomplished through a laboratory lesson. Pupils should be asked to locate cells in various stages of the mitotic process, and draw diagrams of these cells. This activity will also give the pupils additional opportunities to develop skills and techniques in using the microscope as he identifies cells in various stages of mitosis.

AV Aids

SUPER 8 FILM LOOPS

Ameba Proteus. Studies the life processes of this protozoan.

Mitosis. Continuous process by which cells reproduce during division.

TRANSPARENCIES

Ameba. 4 overlays (AV List 8250). Presents asexual reproduction.

Mitotic Figures. 8 flaps (AV List 8292)

16 MM FILM

Mitosis and DNA. (AV List 110.201) Shows division of living cells and steps in mitotic process.

Topics for Reports

The teacher may wish to assign one or more of the following topics to pupils. Pupils should be directed to write clear, concise reports, including pictures and diagrams where possible. The teacher should aid the pupils in locating sources of information by giving pupils a list of reference sources, where material on specific topics may be obtained.

1. Reproduction in Bacteria
2. Fermentation
3. Production of Cheese
4. Stages in Mitosis
5. The "Bloom" of the Grape (Yeasts)

◆

5. HOW CAN NEW PLANTS BE GROWN WITHOUT USING SEEDS?

Outcomes

- Some new plants may be grown from parts of the plant, such as the root, stem, or leaf.
- In plants, this method of asexual reproduction is known as vegetative propagation.

NOTE: It will be necessary to prepare materials for this lesson several weeks prior to its presentation. Materials should be grown as follows.

1. Carrot: partially submerged in water
2. Sweet potato: partially submerged in water
3. Bryophyllum or Begonia leaf: on damp blotter
4. Geranium cutting: set in damp sand
5. Onion: root end partially submerged in water
6. Potato: partially submerged in water.

Motivation

Display a geranium plant. Have pupils identify the principal parts of the plant: leaf, stem, root, and flower. Ask, "How does the geranium reproduce?" Elicit that the geranium reproduces sexually by means of seeds produced by the flower. Point out that some plants can also reproduce asexually.

Development

The teacher can refer to grade 7 Biology in which the pupils had some experience in growing things. In this lesson, pupils will learn which parts of the plant the vegetative structures come from.

1. Show a vegetating carrot or sweet potato. Which principal part of a plant does the carrot or sweet potato represent? Elicit that the carrot or sweet potato is actually the root of the carrot or sweet potato plant. Have pupils identify the growing secondary roots and new stems and leaves. Elicit that the carrot or sweet potato plant is able to reproduce asexually by means of the root.
2. Display a vegetating bryophyllum or Begonia leaf. Elicit that these plants reproduce asexually by means of the leaves. Display newly forming plants on the leaf.
3. Display a vegetating geranium cutting. Which principal part of the plant does the cutting represent? Have pupils point out new roots forming. Elicit that the geranium plant can reproduce asexually by means of the stem. Identify this as a *cutting*.
4. Display chart "Types of Reproduction" (S-1,12-1948). Identify these means of asexual reproduction in plants as *vegetative propagation.* Point out specialized vegetative structures used by some plants, through growing materials or the chart.

Vegetative Structure	*Plant Part*	*Example*
Tuber	Underground Stem	Potato
Runners	Stem	Strawberry
Layering	Stem	Raspberry
Rhizome	Stem	Grass, Fern
Bulb	Stem	Onion, Lily, Tulip
Corm	Stem	Gladiolus, Crocus

5. *If possible, exhibit a seedless orange or grape. "If this fruit does not produce seeds, how can new plants be grown?"*

   Elicit that man has been able to produce special varieties of fruits, such as seedless oranges and grapefruits, large disease-resistant apples, and seedless grapes by artificial vegetative propagation. This process is called grafting.

   Display two twigs. Tell the class one represents a branch on an orange tree that bears oranges with seeds. Let the other represent the branch of an orange tree that bears seedless fruit. Identify these as stock, *the part the graft will be attached to, and* scion, *the small part to be grafted. Cut both ends at acute angles with a clean sharp knife, and fit the cut ends together. Tie it with string and cover it with protective material. Why is it necessary to place the growing layers in each branch together? Why is this the only way to propagate seedless varieties of fruit? Elicit that seedless varieties cannot reproduce normally.*

Summary

1. Why is vegetative propagation considered to be a form of asexual reproduction?
2. How do strong winds or storms aid in propagation of begonia plants?
3. Why is it that new tulip plants will grow year after year without seeds being planted?
4. *Why are cuttings an important method of artificial vegetative propagation?*

Homework

1. Place an onion, potato, carrot, or sweet potato in a jar of water so that about one-half of it is under water. Observe the growth that takes place over several weeks. Keep careful records of the growth of your plant.
   a. Which principal part appears first? Why do you think it is important for this part to appear first?
   b. From which area on the vegetative structure did the roots, stems, and leaves appear?

2. A farmer has an apple tree that is resistant to disease yet produces a small tasteless fruit. He has another tree which produces large tasty fruit, but is not resistant to disease. How can he produce large tasty fruit on his tree which is resistant to disease?

Materials

Vegetating parts of plants: sweet potato, onion, carrot, bryophyllum or begonia, geranium cutting.

Potato tuber
Crocus or gladiolus corm
Geranium plant

2 twigs
String
Sharp knife

6. HOW DO ANIMALS REPLACE LOST PARTS?

Outcomes

- Some animals are able to grow new parts to replace parts that have been lost.
- Some animals may grow from parts of animals of the same kind.
- These processes are called regeneration.

Motivation

Relate the following story to the class:

By eating the oysters, starfish were depleting oyster beds. Oyster-fishermen, wanting to destroy the starfish, caught them, cut them up, and threw the pieces back into the water. This, however, made matters worse; they now had more starfish than they had had before. Permit pupils to venture suggestions as to why the number of starfish increased.

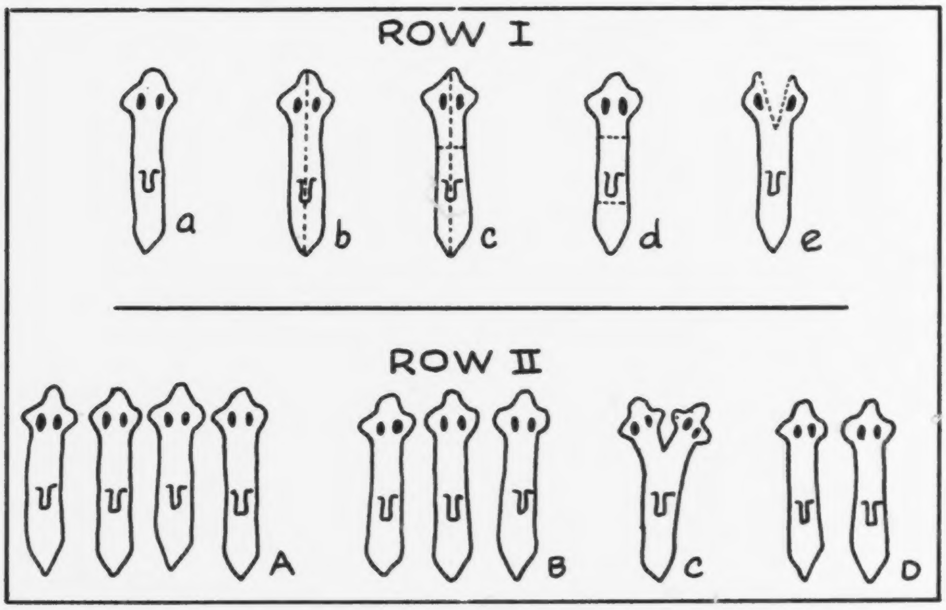
Development

1. Elicit that the starfish has the ability to grow a complete new organism from a part. Further elicit that other organisms also have the ability to grow from parts. Identify this process as *regeneration.* The glass snake, a form of lizard, and many other lizards are able to break their tails off and regenerate the lost tails. How do these

animals use this device for protection, when attacked by other animals? Point out that regeneration may also be defined as regrowth of lost parts.

2. Explain to pupils that planaria worms have the ability to regenerate a new organism from a part. Duplicate the following chart for distribution to pupils. Point out that Figure a (Row I), represents a whole planaria worm. Figures b, c, d, and e (Row I), represent planaria worms which have been cut into segments as shown by the dotted lines. Ask pupils to match the regenerated worms in Row II, with the cut worms in Row I. Elicit that each part will regenerate to form a new organism.

   Problem: How would you cut a planaria worm so that it regenerated with 2 heads and 2 tails?



3. Place several specimens of tubifex worms into a clean Syracuse dish.

   NOTE: Tubifex worms can be easily obtained from most pet shops. Use aquarium water only.

   Make a transverse cut, with a clean scalpel, through each worm. Separate the sections into individual Syracuse dishes, containing clean water and a small piece of lettuce or a water plant. Exhibit the cut specimens to the pupils. Ask pupils what they think will happen. Elicit that if tubifex worms can regenerate, each piece will grow into a new organism. (It takes about 2 weeks, at room temperature, for regeneration to be completed.) Tell pupils that they will make final observations at a future date.

4. *Ask, "Can man regenerate lost or worn-out parts?" Elicit that man is unable to regenerate most lost or worn-out parts. Point out that the nearest man does come to regeneration is the healing process, the replacement of blood cells, and the repair of small sections of some tissues. How has man attempted to overcome his inability to regenerate lost or worn-out parts? Point out that through transplants and artificial devices, man has been able to replace many organs which were lost through disease or accident. At this time you may wish to discuss some of the recent advances in transplant surgery: heart, liver, lungs, kidney, cornea, bones, blood vessels, etc.*

Summary

1. Why is regeneration considered to be a form of asexual reproduction?
2. Give some examples of man's regenerative abilities.
3. *Why are many hospitals setting up organ and tissue banks?*

Homework

1. List 5 methods of asexual reproduction among plants and animals. What special advantages does each of these have as a means of reproduction?
2. *What is autotomy? How does autotomy in a lobster differ from regeneration in planaria?*
3. *Why is the regeneration of a lobster's claw not considered a form of reproduction?*

Materials

Tubifex worms
3 Syracuse dishes
Lettuce or water plant
Scalpel

◆

REINFORCEMENT AND REVIEW (5-6)

Test

This is a cross-section of several types of questions, which might be used as a model in constructing a test on asexual reproduction.

MULTIPLE CHOICE

1. The process of reproduction, in which an organism divides equally to form two new individuals, is called (a) budding (b) binary fission (c) sporulation.
2. An organism that reproduces by budding is (a) an ameba (b) yeast (c) paramecium.
3. A plant that reproduces vegetatively by means of tubers is (a) the tulip (b) the onion (c) the potato.
4. The process by which animals grow back lost parts is called (a) regeneration (b) vegetative propagation (c) budding.

FILL IN

1. The process by which cells divide to form new cells is called __________.
2. Bread mold reproduces by forming tiny "seeds," which are resistant to temperature extremes and drying. These "seeds" are called __________.
3. Mitosis insures an equal division of __________.
4. The type of reproduction that involves only one parent is __________.

ESSAY

1. How does sexual reproduction differ from asexual reproduction?
2. Why is grafting used in the production of seedless oranges?
3. Explain how budding differs from binary fission.
4. How does mitosis insure an equal division of chromosomes?

MATCHING

Match the vegetative structure in Column *B* with the plant in Column *A* it comes from.

A	*B*
1. carrot	a. bulb
2. onion	b. stem cutting
3. strawberry	c. root
4. geranium	d. leaf
5. begonia	e. runner

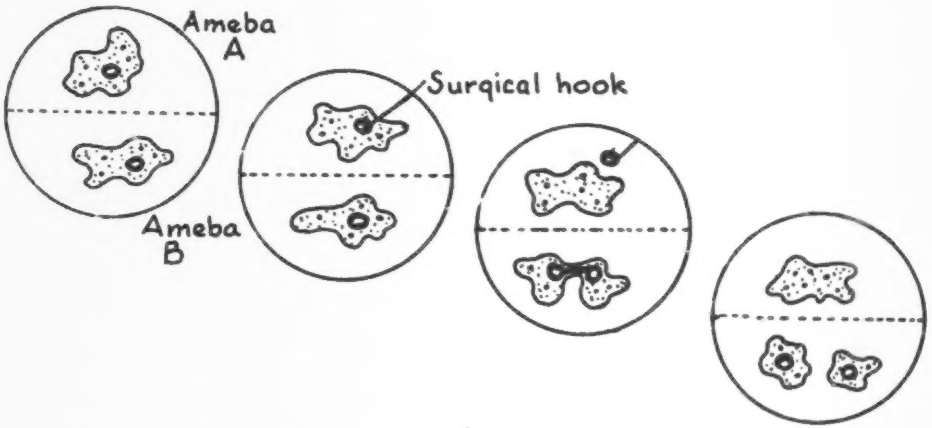
Topics for Reports

The teacher should inform pupils of reference sources and where they may be found.

1. Artificial Organs
2. Transplant surgery: Heart, Kidney, Cornea, etc.
3. Autotomy
4. Grafting
5. Cuttings as a Means of Artificial Vegetative Propagation
6. Dr. Samuel M. Nabrit's Work in Regeneration

This exercise is designed to train pupils in the interpretation of charts and pictures and to make careful observations of scientific phenomena.

Have pupils study the pictures carefully. Have the pupils write an explanation of what the pictures tell them and also to list their observations and conclusions.



SEXUAL REPRODUCTION

Suggested Lessons and Procedures

7. WHAT ARE THE PARTS OF A FLOWER?

LABORATORY LESSON

Outcomes

- Flowers are the parts of the plant where seeds are made.
- The two important parts of the flower which reproduce the plant are the pistil and the stamens.

Development

1. Teach the parts of the flower.
2. Explain how seeds are formed.
3. Distribute mature gladiolus with Worksheet and materials listed. Guide pupils in performing the laboratory activity. When necessary, assist them in reading the directions.

Summary

Following the laboratory experience, use the questions and the conclusions on the laboratory sheet as a basis for a lesson summary.

(MAY BE DUPLICATED FOR USE BY PUPILS)

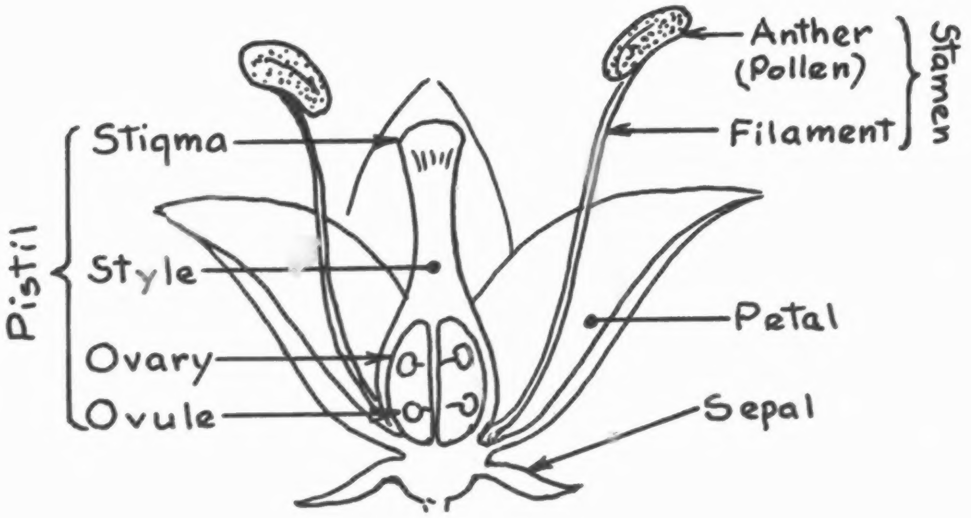
LABORATORY WORKSHEET—BIOLOGY: LESSON 7

Problem: What are the parts of a flower?

Materials

Flower
Single-edge razor blade
Hand lens
2 sheets of white paper
Forceps

Procedures and Observations



1. Carefully remove the green leaves at the bottom of the flower, and then the petals. (Save them for part 6.)
2. Examine the parts that are left over in the center and compare them with those in the diagram. You may use this diagram to help you name the parts of *your* flower.
3. How many stamens are there? ______________. Remove one of the stamens at the base, using the forceps. What is the knob-like thing at the top called? ______________. Brush some of the powdery material from the anther onto a sheet of white paper. You may use the edge of the forceps to do this. Examine this powder with a hand lens. Draw what you see.

   What are these particles called? ______________.
4. Remove all the stamens from your flower. What part of the flower do you now have left? ______________. How does the bottom part of the pistil differ from the rest of it? ______________. This part is known as the ______________.
5. Place the pistil on a sheet of paper. Using the razor blade, carefully and slowly, cut through the ovary lengthwise. Separate the two halves and examine with a hand lens. Try to remove some of the rounded objects that you see and examine them further. What do you think they are? ______________.

6. *Look at the petals and the green parts (sepals) of the flower. Describe them as to color, odor, appearance, touch. How do they help the plant?*

Conclusions

1. The two essential (important) parts of a flower are ______________ and ______________.
2. The top of the stamen is called the ______________.
3. It produces a powdery substance which we call ______________.
4. The bottom of the pistil is the ____________ in which ______________ are found.
5. Each flower has (one, more than one) ______________ pistil(s) but (one, more than one) ______________ stamen(s).
6. *What do you think the petals and sepals do for the plant?*

Homework

1. Why are flowers important to plants?
2. Visit a friend who grows flowers or has a flower shop. Find out the names of a few flowering plants and something interesting about each. If any are imported, find out where they grow naturally.
3. If a certain disease were to attack all apple trees and destroyed their flowers, what would happen? Explain your answer.
4. *Many people suffer from hay fever in August and September. Find out what causes it and how it may be treated.*
5. Optional: Buy seeds of a flowering plant, such as marigolds, in a "five and dime" store. Read instructions for planting (on package). When the plant is grown, bring it to school for further study.

8. HOW DOES POLLINATION TAKE PLACE?

Outcomes

- Pollination is the transfer of pollen from a stamen to a pistil.
- Pollen may be transferred in several ways through such agents as insects, wind, birds, and man.

- *There are two types of pollination:*
  - *Self-pollination: pollen from an anther settles on the pistil of the same flower.*
  - *Cross-pollination: pollen is transferred from one flower to another flower of the same kind.*

Motivation

Show charts or pictures of insects, such as bees, visiting flowers. Have pupils note that the insect's bodies are covered with pollen on leaving a mature flower.

Development

1. Using a model of a flower, review the essential parts of a flower.
2. a. Elicit from the pupils that insects and some birds (hummingbirds) visit flowers for the purpose of collecting food (nectar). In the process, some of the pollen brushes off the anthers and sticks (adheres) to their bodies.

   b. Ask, "What might happen when these insects visit other flowers?" (Some of the pollen they carry will be left on the flowers.)

   c. Tell the pupils that the transfer of pollen from flower to flower is called pollination.
3. a. Display preserved specimens, pictures, or chart #12-3098.02 of flowers, grasses, corn, and some trees (maple, elm). Tell pupils that most people do not associate flowers with these plants.

   b. Ask, "Do you think insects will visit such flowers?" "Why not?" (They are unattractive and odorless.)
   Ask, "How then may pollination in such plants occur?" Elicit that wind may blow pollen about and enable it to reach other flowers. Relate this to the reason why some people sneeze during the flowering season.
4. *Tell the pupils that, at times, scientists or plant breeders wish to use only the pollen of certain selected plants for pollination. "How can you keep unwanted pollen from pollinating a flower?" (Cover the flower with a plastic bag and remove it only for pollination.) Tell the pupils that this kind of pollination is called artificial pollination. Why?*

5. *Show the class a model or pictures of a sweetpea flower. Ask pupils to describe the blossom, especially noting that it is completely closed. Ask, "How can pollination in such a flower take place?" Elicit from pupils that the only possible method is self-pollination.*

Summary

The questions below may be placed on the board or used as a quiz.

1. In the process of pollination, ________ is transferred from ________ to ________.
2. Three ways in which pollination may occur are ________, ________, and ________.
3. Insects visit flowers for the purpose of ________.
4. Corn plants are pollinated by ________.
5. *There are two types of pollination: ________ and ________.*
6. *An example of self-pollination is ________.*
7. *When man himself selects pollen of certain plants for pollination, we call it ________ pollination.*

Homework

1. Explain how insects help the process of pollination. Give two examples.
2. How are most of the weeds and grasses on an empty lot pollinated? Explain your answer.
3. DDT is a poison that kills many insects. How do you think this might affect flowers?
4. *Read about the work done by Luther Burbank. How did he use pollination to create new varieties of fruits, such as a nectarine or plumcot?*

Materials

(Materials continued — next page.)

Model of typical flower
Charts on pollination
Pictures of insects and birds visiting flowers

Charts (S-I 12-3098.02) *(Continued)*
Pictures or specimens of flowering grasses, maple, elm, corn
Model or chart of sweetpea flower

NOTE: For Lesson 9, prepare germinating pollen grains. This should be done at least a day prior to lesson. (Prepare several slides.)

Instructions: Ring a depression slide with vaseline. This may be done by dipping the mouth of a test tube, slightly larger in diameter than the depression, into vaseline and pressing it on the slide. Into a drop of table sugar solution (10% - 20%) in the center of a clean coverslip, shake some mature pollen. Invert the coverslip over the depression and gently press against the vaseline. Place the slide in a warm place.

9. HOW ARE SEEDS FORMED?

Outcomes

- **Upon landing on the stigma, the pollen grain grows a tube down to the ovary, where the pollen nucleus unites with the ovule nucleus. This union is called fertilization.**
- **The fertilized ovule develops into a seed.**
- ***A sweet, sticky substance on the stigma holds the pollen in place and provides it with energy for growth.***
- ***In many plants, a number of grains grow down to the ovary to fertilize several ovules, thus producing a number of seeds.***

Motivation

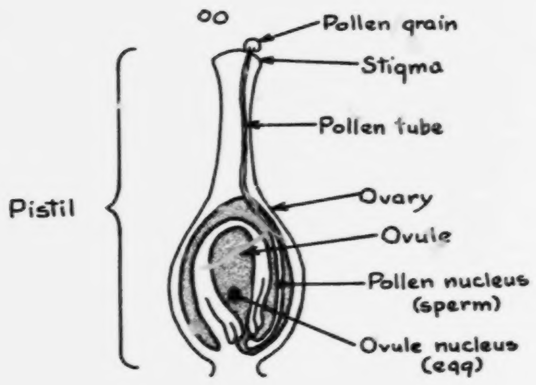
Using a bioscope or a tri-simplex microprojector, show the class the germinating pollen grains which were prepared the day before. Be sure to include one slide of nongerminating pollen (in plain water) as a control. Direct pupils to observe: some grains with no tubes, some with short tubes, some with longer ones. Complete the motivation by asking, "How does the pollen tube help the plant make seeds?" (Tell class the answer will be revealed as the lesson progresses.)

Development

1. Have the pupils make simple diagrams of three pollen grains

showing various stages of the pollen tube. (With some pupils, you may introduce the term *germination* in referring to these stages.)

2. Distribute reproduced diagrams of a longitudinal section of a pistil. Omit labels. Pupils refer to the diagram during the lesson and add the labels.



3. As the lesson progresses, write the new terms on the board and direct the pupils in properly labeling the diagram.
   a. Ask, "On what part of the pistil does the pollen land?" (Stigma.)
      "In what part of the pistil are the ovules found?" (Add ovary and ovule labels.)
   b. At this point explain that the important thing that happens in seed formation is that the nucleus of the pollen unites with the nucleus of the ovule. This union is called *fertilization.* Stress the fact that everything that precedes this union is mere preparation for it and that a seed cannot be formed unless fertilization occurs. Now ask, "How can the nucleus of the pollen reach the nucleus of the ovule?' (Label pollen tube, pollen nucleus, ovule nucleus). Elicit that the pollen nucleus moves down the tube into the ovule and fertilizes it.
   c. The fertilized ovule will then develop into a seed.

4. *The stigma is covered with a sweet, sticky substance which keeps the pollen grains in place and provides them with sugar to be used for energy for growth of the tube.*

5. *Referring to a chart or a model, point out that a number of pollen grains land on a stigma. Then ask, "What will happen to all of*

them? What will determine how many seeds will be formed? If an ovule is not fertilized, what will happen to it?"

Summary

1. A pollen grain must land on the __________ of the pistil to take part in seed formation.
2. It then grows a __________ down to the pistil to the ovary in which the __________ are located.
3. In the ovule, the __________ of the pollen unites with the __________ of the ovule. This union is called __________.
4. The fertilized ovule will develop into a __________.
5. *The germination of the pollen tube is made possible by the energy provided by the __________ on the stigma.*
6. *The pistils of most flowers have (one, more than one) __________ pollen grains germinating because most flowers have __________ ovules in their ovaries.*

Homework

1. If, for some reason, pollen could not land on a certain flower, what could not be made? Explain your answer.
2. How does the pollen tube help to make a seed?
3. Is the seed a result of sexual or asexual reproduction? Why?
4. *Obtain pollen from a mature flower. In three separate small vials, place a few drops of water in one, a few drops of dilute sugar solution in the second, and a few drops of dilute salt solution in the third. Brush pollen grains into each vial, seal it, and place in a warm place. Examine the contents under a microscope in school with your teacher's permission and report the results to the class.*

Materials

Bioscope or tri-simplex microprojector
Slides of germination
Pollen, previously prepared
Reproduced diagrams — germination and fertilization
Chart — pollination and fertilization (S-I 12-2548)

10. WHAT IS A FRUIT?

Outcomes

- The enlarged ovary containing ripened seeds is called a fruit.
- The fruit protects the seeds inside and provides them with food.
- All races have contributed foods which are now accepted in the diet of the American family.
- *While the newly-formed seeds are developing, food and water are stored in the ovary, enlarging it many times.*
- *Fruits help plants to scatter the seeds (seed dispersal) when they are ripe.*

Motivation

Display several different kinds of fruit in season (apple, peach, orange, tomato, string bean, whole nut, etc.) Ask, "What do all of these have in common?" Do not refer to them as fruits at this time. If the correct response (they all have seeds inside) is not made, cut open each and repeat the question. (It is suggested that some fruits be cut across to show the arrangement of seeds in x-section, while others may be cut longitudinally.)

Development

1. Review seed formation, stressing the fact that the fertilized ovule develops into a seed while still within the ovary.
2. a. By referring to the cut fruits displayed in the motivation, ask, "Which of these are fruits?" (It is doubtful that the tomato, string bean, and nut will be so designated.) Lead the pupils to the conclusion that any part of the plant that contains seeds is a fruit.

   b. Elicit from the pupils several examples of fruits which are generally considered vegetables. (Pepper, cucumber, pumpkin, coconut with husk, etc.)

   c. Draw simple diagrams on the board of cross- and longitudinal sections of a typical fruit (apple). Have pupils label the seeds and the ovary, and then copy the labelled drawings into their notebooks.

d. Discuss what happens to the parts of the flower after fertilization. By examining the fruits, have the pupils note whether there are many remains such as stem and sepals of the flower.

3. a. Ask, "How do most ripe fruits taste?" (Sweet and juicy.) "Why does nature store food (sugar) and water in fruits?" (To keep the seeds alive.)

   b. Ask, "Is it better for the seeds to be in the center or near the outside of the fruit?" (Center.) "Why?" (Seeds are better protected that way.)

4. a. Elicit that when a fruit is first formed, it is small and the seeds very immature. If available, show a small branch from a cherry tree or some other fruit tree, with a few newly formed fruits. Guide pupils to the understanding (refer to photosynthesis, taught in 7th grade) that the food-making process in plants stores large quantities of food and water in the old ovary, thus enlarging it many times.

   b. While the fruit is growing in size, the seeds within develop to maturity.

5. Using a chart (seed dispersal 12-2558), discuss how fruits help in the dispersal of seeds and what adaptations there are for dispersal by wind (maple), water (coconut), animals (edible fruit), mechanical means (witchhazel).

6. Trace the country of origin of some fruits which are commonly accepted in the United States as food.

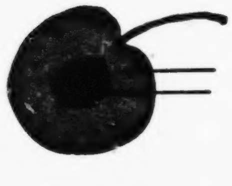
   Various fruits which are now readily available and considered part of the "American" diet had their origins in various parts of the world. From the natural to the cultivated form required skill and experimentation by groups of people before their introduction into the United States.

   Tell the pupils that South American Indians helped introduce the tomato, pineapple, and coffee; China contributed the banana and orange; while the Indians of Central America contributed squash, corn (maize), avocado, and bean. The mango fruit has its origin in the tropical areas of Central Africa.

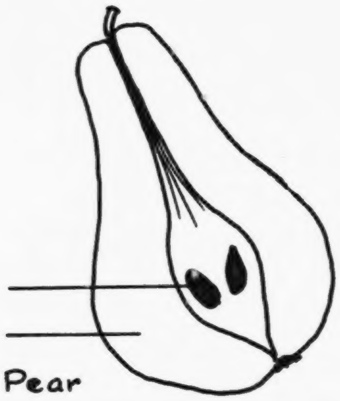
   Ask, "What do you think the people of the Near East have contributed?" (Cherry, melon, grape, apple, and fig.) Refer to biblical stories for reference to various fruit.

Summary

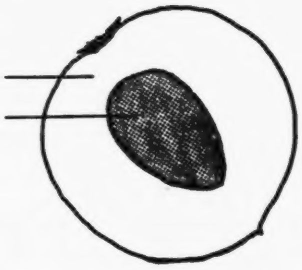
1. Is a green pepper a fruit? ____________ Give the reason for your answer. ____________
2. In what two ways are fruits helpful to seeds?
   a. ____________ b. ____________.
3. Label the seeds and ovaries in the following drawings.



Cherry



Pear



Peach

4. Point out that the lands of origin of all races have contributed foods which are now accepted in the diet of the American family.

Homework

1. a. Visit a fruit store or a supermarket in your neighborhood. On a sheet of paper, write the name of every item that you think is a fruit. (If you do not know the name of any, ask someone.) Why did you select the ones you did?
   b. Find out if any of the fruits are brought in from outside the United States. What countries are they from?
2. a. Is a peanut with a shell a fruit? Why?
   b. How does the shell help the seeds inside?
3. *In a field, a distance away from the forest, a young maple tree started to sprout. How could this have happened?*

Materials

Chart on seed dispersal (12-2558)
Several fruits in season
Examples of fruits in early stages

Note: For the next lesson, soak lima beans overnight. Have a sufficient number, plus a few extras, for each pupil. Make sure there is enough water to prevent evaporation overnight.

11. WHAT IS A SEED MADE OF?

LABORATORY LESSON

Outcomes

- The tiny, undeveloped young plant in a seed is the *embryo.*
- A seed consists of the embryo, stored food, and a protective coat on the outside.
- The food in the seed is used as a source of energy for the new plant when it starts growing.

Development

1. Distribute the Worksheet and the materials on trays.
2. Caution pupils regarding the proper use of the scalpel by demonstrating it in this activity. Be sure to collect the same number of scalpels as were distributed.
3. As an extension of the lesson, the teacher may have pupils observe germinating bean seeds. This may be prepared either by the teacher or pupils at home. Soaked beans are placed between wet blotters and the inner surface of a jar and observations made over a period of a week. The pupils should note that as the embryo develops, the cotyledons shrivel up because the stored food is being used up.

Summary

Refer to the conclusions at the end of the laboratory lesson.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 11

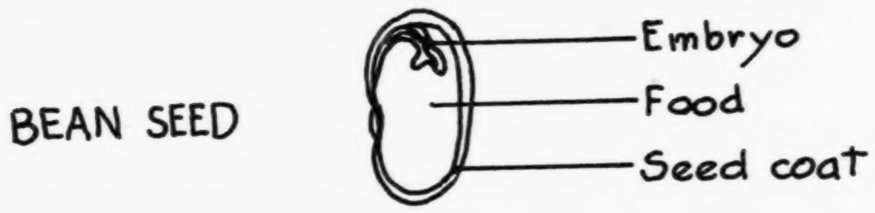
Problem: What is a seed made of?

Materials

Soaked lima bean
Hand lens
Scalpel (or single-edged razor blade)
Forceps
Glass slide
Lugol's solution

Procedures and Observations

1. Examine the seed coat which has been loosened by the soaking. Of what use is it to the seed? ________.
2. a. Make a small cut in the seed coat with the scalpel. Then, carefully strip away the seed coat with the forceps. Separate the two halves of the seed very gently and place them on a sheet of paper.
   b. Using the hand lens, examine the little curved part near the edge of one of the halves. This is the young, undeveloped plant that we call the *embryo.*
   c. To the left of the diagram, draw exactly what *you* see in *your* bean seed. Label the parts. How does your seed differ from the diagram on the right?



3. Using the scalpel, cut one-half of the bean seed (cotyledon) into several sections and place on a glass slide. Add a drop of Lugol's solution to the cut surfaces. What change do you observe? ________________________
____
Why does this happen? ________________________
4. Compare the size of the entire seed with the embryo. Most of the seed consists of ________ stored there for the embryo.

Conclusions

1. The seed is protected by a tough, outer ________.
2. Within the seed is a small, undeveloped plant called the ________.
3. Nature stores food in the seed to provide the embryo with ________ when it starts to grow.
4. Lugol's solution shows that the nutrient ________ makes up much of this food.
5. The size of the seed depends upon how much ________ is stored in it.

Homework

1. We eat many kinds of seeds. Some are canned and some are dried. In a grocery, or a supermarket, examine the shelves and, on a sheet of paper, list all such items.
2. We eat seeds because nature stored food in them. Why did nature do this?
3. How can you tell if seeds have starch in them?
4. Do seeds need protection? How is this done?

◆

REINFORCEMENT AND REVIEW (7-11)

Following are some suggestions that may be useful for review, reinforcement, or enrichment. The activities selected may vary from class to class and may include additional ones not described here.

Tests

REARRANGING

Below are eight statements in regard to seed formation. Rearrange them so that they occur in the proper order.

1. From each pollen grain, a tube grows down the pistil.
2. The seeds and ovary together develop into a fruit.
3. Pollen is produced in the stamen.
4. The nucleus of the pollen grain flows down the tube into the ovule.
5. The pollen lands on the stigma.
6. The ovule nucleus and the pollen nucleus unite.
7. When pollen is ripe, wind or insects may carry it to other flowers.
8. Fruits help in the scattering of seeds.

MATCHING

In front of each word in Column A, write the number from Column B that best describes it.

A	B
_____embryo	1. agent of pollination
_____pollination	2. contains the pistil and stamens
_____fertilization	3. the young plant in a seed
_____seed	4. an ovary with seeds inside
_____pistil	5. the embryo and stored food
_____insect	6. transfer of pollen
_____fruit	7. contains ovules
_____cotyledon	8. results in seed formation
_____tomato	9. a fruit because it has seeds
_____flower	10. contains stored food
	11. always brightly colored

Activity

Pupils may bring to class the germinating bean seeds started in a previous lesson. They are to observe each others' seedlings and compare results. Conclusions should be reached from the composite results.

Filmstrip

Seeds and Seed Travel. 38670.11
This strip shows parts of the seed and methods of seed dispersal.

Topic for Report

Luther Burbank. Have pupils report on his work and the methods he used to produce new and valuable varieties of fruits.

◆

12. WHAT PARTS OF AN ANIMAL ENABLE IT TO REPRODUCE SEXUALLY?

Outcomes

- Animals have special cells for sexual reproduction. The female sex cell is called an egg cell. The male sex cell is called a sperm cell.
- Egg cells are formed in an organ called the ovary, sperm cells in the testis.

- *Egg cells and sperm cells leave the body through tubes after they are mature.*

Motivation

Tell the class the story of the Pacific coast salmon during the spawning season as it overcomes many obstacles in swimming upstream (Columbia River) to find a place to deposit its eggs. Do not neglect to mention that the male fish also participates in this journey so that eggs may be fertilized.

Development

1. Briefly review sexual reproduction in flowering plants. Emphasize the reproductive cells (pollen and ovules) and the organs in which they are produced. "Are there similar organs in animals which produce cells for reproduction?" Identify the cells produced by the ovary of animal forms as the egg cells. The male sex cells are called sperm cells.

2. a. Display preserved specimens, models, or charts of different animals showing the ovaries and testes of both male and female organisms (frog, fish, etc.).

   b. Point out the ovaries and testes in the fish. Then ask pupils to locate these organs in the other animals.

   c. Ask, "What parts were found in plant ovaries?" (Ovules.) Lead the pupils to conclude that animal ovaries have a similar function: they produce egg cells.

   d. Similarly, relate the testes to the anther. Direct the pupils to the conclusion that the testes are organs where the male sex cells, called sperm cells, are formed.

3. *Explain to the class that in most animals, the ripened eggs and sperm cells are expelled from the bodies to the outside. Locate the* oviducts *in the female and the* vas deferens *in the male. Point out that these are tubes through which the sex cells travel. They end as openings in the rear of the body.*

4. Develop the understanding that *all* higher forms of life, including man, have specialized organs (ovary, testis) to produce sex cells (egg cells, sperm cells) for reproduction.

Summary

1. Name the female sex cells in plants and animals. __________, __________.
2. Name the male sex cells in plants and animals. __________, __________.
3. In what organs are eggs produced? __________ In what organs are sperm cells produced? __________
4. Which animals carry on sexual reproduction? __________.
5. *How do eggs leave the body of the female?* __________
6. *How do sperm cells leave the body of the male?* __________.
7. *Why is an earthworm called a bisexual animal?* __________.

Homework

1. Name the animal parts which are similar to the following plant parts: anther ______, pollen ______, ovary ______, ovule ______.
2. Visit a neighborhood fish market. If the owner has time, ask him to show you fish eggs (roe) of several different kinds of fish. On a sheet of paper briefly describe the eggs by giving the name of the fish, color of eggs, size of eggs (you may draw it), number of eggs (few, many, very many).
3. *The eggs of certain fish are a delicacy. Report on the preparation of such eggs for our consumption.*
4. *Find out what happens to birds' eggs (such as a chicken) after they leave the ovary until they are laid. Report to class.*

Materials

Dissected fish, frog, bird
(to show gonads)
Models of reproductive organs
of animals
Chart of frog anatomy (12-2668)
Fish eggs (fresh or preserved)
Model of earthworm (12-3918)
Chart of earthworm (12-2738)

13. HOW ARE EGG CELLS FERTILIZED?

Outcomes

- Egg cells are larger than sperm cells because they contain stored food.
- A sperm cell is equipped with a tail for movement.
- When the sperm reaches the egg, fertilization takes place.
- *To prevent other sperm cells from entering the egg, a membrane is formed around it after fertilization.*
- *There are many more sperm cells produced than egg cells.*

Motivation

Ask, "How large are cells?" (Microscopic.) Then display some fish eggs, frog eggs, chicken eggs. Tell the class that each of these is really a single cell. Ask, "Why are eggs so large?" Lead the pupils to the understanding that eggs contain food for the embryo that will develop within it.

Development

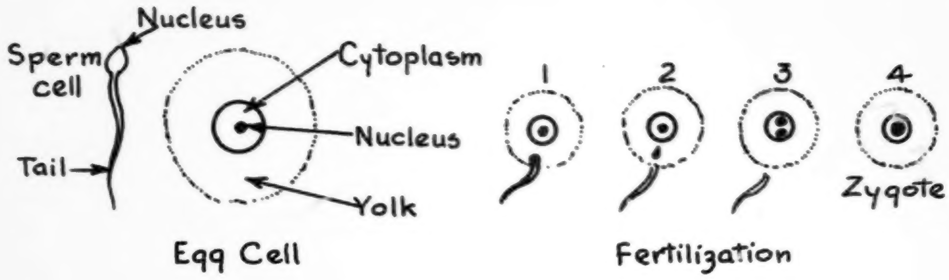
1. Using a chart on reproduction (S-1, 12-1948), have pupils compare an egg cell with a sperm cell in size, shape, and appearance.
2. a. Ask, "Why do you suppose we cannot see individual sperm cells the way we see eggs?" Elicit the fact that sperm cells are extremely small, have no stored food, and the nucleus is the bulk of the cell.

   b. Sperm cells may be prepared for microscopic study in the following way: remove the testes from a freshly dissected frog. Tease them apart with forceps in a Syracuse or Petri dish containing a few cc's clean water. Mount a drop of this material on a slide and, using a small diaphragm opening, examine under low and high power. (Dilute methylene blue may be added for better visibility, but this will kill the sperm.) Pupils should observe that sperm are very small and are motile.
3. a. By referring to Lesson 9 (How Are Seeds Formed?), develop the need for fertilization in animal reproduction.

b. Point out that since eggs are much larger and heavier than sperm, they are stationary.

c. Ask, "How can the sperm reach the egg to fertilize it?" The need for some propelling device in a liquid should be understood. By referring to the chart, elicit from the class that a whiplike tail enables the sperm cell to do just that.

d. With the help of the chart and the reproduced diagram shown, have pupils describe what happens as fertilization takes place. The term *zygote* may be introduced as a fertilized egg cell.



FERTILIZATION IN A FISH

Stress that when fertilization occurs, a new organism is created. This occurs in all organisms that reproduce sexually.

4. a. *Lead the pupils to the understanding that the possibility of a particular sperm fertilizing an egg is very small. Some sperm cells never reach eggs. Others are destroyed by various conditions. Therefore, many more sperm cells are formed than are needed for fertilization.*

b. *To prevent abnormal offspring (descendants), only one sperm cell penetrates the egg. Immediately after fertilization, a membrane is formed around the egg cell, thus preventing other sperm cells from entering it.*

Summary

1. List three differences between an egg cell and a sperm cell. __________, __________, __________.

2. Why is a sperm cell equipped with a whiplike tail?

3. What must happen to the sex cells during the process of fertilization in animals?

4. *How is an egg cell prevented from being fertilized by more than one sperm?*
5. *Why do animals produce many more sperm than eggs?*

Homework

1. We use eggs as food. Why is there so much food stored in them?
2. Describe what happens to the egg cell and a sperm cell when fertilization takes place.
3. What would happen to most living things if fertilization were to stop? Why?
4. *Prepare a report about reproduction in tropical fish. Include information about fish which lay eggs and those that bear young alive.*

Materials

Eggs of various animals (frog, fish, birds, etc.)
Chart: Types of Reproduction (S-1, 12-1948)
Frog's testes

Forceps	*Slide*
Syracuse or Petri dish	*Water*
Microscope	*Dropper*

14. WHAT HAPPENS TO A FERTILIZED EGG?

Outcomes

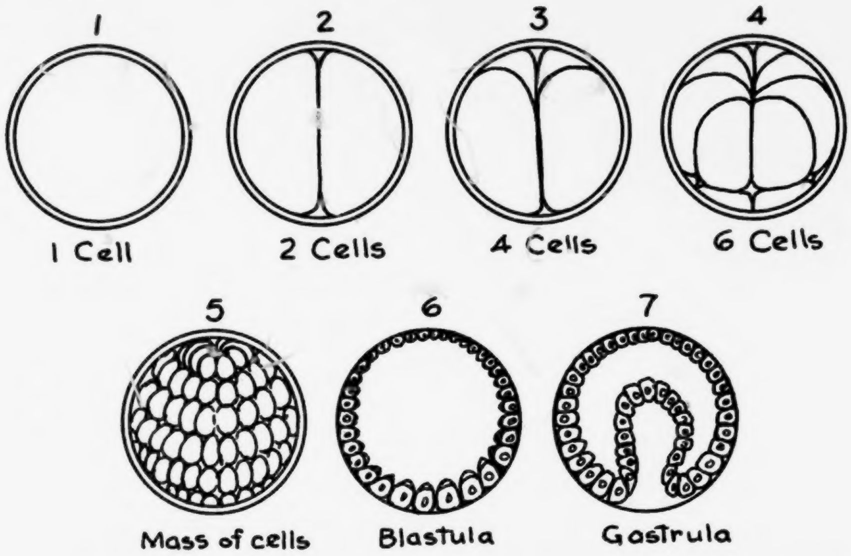
- After fertilization, the egg cell divides many times, forms a mass of cells, and develops into an embryo.
- The early stages in the development of most animals look alike.
- *This resemblance is used by scientists as proof that all organisms had common ancestors in the distant past.*

Motivation

By referring to the previous lesson, elicit that all animals that reproduce sexually start out life as a single fertilized egg cell. At birth, animals are made of millions of cells. Tell the pupils that in this lesson, they will learn about some of the stages in the development of the embryo following fertilization.

Development

1. Using a microprojector and slides (#12-8978; #12-6938) show the class the early stages in the development of the starfish embryo. Impress upon the pupils that what they are about to see is typical of all animals that develop as a result of fertilization.
2. Reproduce the accompanying diagram and distribute it to pupils. They should compare what they see on the screen with the stages in the diagram and use it in answering homework questions.



EARLY STAGES IN THE DEVELOPMENT OF AN ANIMAL EMBRYO

3. a. Locate a fertilized egg cell on the slide. Ask, "How many cells are found in this stage? How many organisms start life in this stage?"
   b. Explain that very soon after fertilization the egg cell undergoes rapid division as the new organism (embryo) starts to develop.
   c. Project slides showing a 2-cell stage, a 4-cell stage, an intermediate stage, and a round mass of cells. By referring to Lesson #2, lead the pupils to conclude that the process of mitosis is involved in the production of these cells. Then ask, "How do these various stages compare in size with the original cell?" The

class should realize that there is not much growth in size in the very early stages. (Slide 12-8978 shows the stages mentioned.)

4. a. Project slide #12-6938 to show the hollow ball (blastula) stage and the indented ball (gastrula stage). Point out that these are later stages in the development of embryos.
   b. *Identify these stages as the blastula and gastrula.*
5. *Discuss with the class the significance of the similarity of these early stages in the embryos of organisms. Ask, "What do these stages tell us about animals in general?" (There is a relationship). "Are we related to single-celled animals? How?" Very briefly discuss the development of complex animals from simple ones.*

Summary

1. How many cells is an organism made of when it begins life?
2. What process takes place rapidly soon after fertilization?
3. How is a round ball of cells formed?
4. What changes take place after this stage?
5. Compare the early stages in the development of embryos of various animals.
6. *How do biologists use this information?*

Homework

1. With the help of the diagram which was given to you in class, answer the following questions:
   a. How was the one-cell stage formed?
   b. What happens to the fertilized egg cell when it develops into a 4-cell stage?
   c. What happens when it forms a round mass of cells?
   d. What part does mitosis play in this development?
   e. Which animals go through these stages?
2. *The gastrula, in a later stage, form a double layer of cells from which various tissues and organs of the body develop. From which*

layer, do you think, would the following arise: nervous system, skeleton, digestive system, skin?

Materials

Microprojector
Slides (12-8978, 12-6938) cleavage stages of development of fertilized egg cell through gastrula
Diagram — early stages in development of animal embryo

15. HOW DO SOME INSECTS DEVELOP?

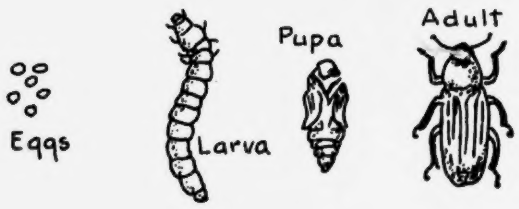
LABORATORY LESSON

Outcomes

- In many insects, the stage that hatches from the egg does not resemble the adult.
- These insects go through four distinct stages: egg, larva, pupa, adult.
- *The more advanced insects undergo* complete metamorphosis. *The more primitive ones undergo* incomplete metamorphosis *(egg, nymph, adult).*

Development

1. The larvae (mealworms), pupae, and adults of the Tenebrio beetle may be purchased in a pet shop. Be sure to request from the dealer *all* three stages. These may be kept in a mixture of uncooked oatmeal and sawdust. It is unlikely that the eggs will be found.
2. Distribute to each group a bottle containing specimens of the three stages of the beetle, forceps, a hand lens, and reproductions of the diagram shown. (If there are any pupils who are squeamish about handling or examining insects, do not insist that they do.)



Summary

Refer to the conclusions at the end of the activity.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET—BIOLOGY: LESSON 15

Problem: How do some insects develop?

Materials

Bottle containing larva, pupa, and adult Tenebrio beetle
Forceps
Hand Lens
Riker mounts or jars showing development of grasshopper

Procedures and Observations

1. Using the hand lens, see if you can find any eggs. Can you think of a reason why you may not find any? ____________________
2. Look for the wormlike stage. This is called a larva. The fertilized egg hatched into a tiny form of this larva. What do you think enabled it to grow to this size? ____________________
(If it is not moving, poke it gently with the forceps and watch its movement. Draw the larva just as you see it and compare it with the one on the diagram. Try to make it the same size as you see it.)
3. Look for the stage in the bottle called the pupa on the diagram. Examine it carefully with a hand lens. Do you notice any kind of movement? ______
This is sometimes called the *resting stage,* although many changes take place inside it. Most insects spend the winter season as pupae. Draw this stage life-size and compare it with the drawing on your diagram.
4. Now examine the adult beetle. How does it compare with the other stages?
5. *These four stages in the life history of many insects are known as* complete metamorphosis. *Some insects go through a less complicated process. Examine either jar or Riker mount of the stages of the development of a grasshopper. What differences do you observe between this development and that in the beetle you studied?* ____________________
Compare a newly-hatched grasshopper (nymph) with the adult. __________
____
This kind of development is called incomplete metamorphosis.

Conclusions.

1. The wormlike stage of many insects is called the ____________________.
2. The pupa seems to be inactive because ____________________.
3. Eggs are laid only by the ____________________.

4. Most insects spend the winter in the ______________ stage.

5. Before an insect egg can hatch into a larva, it must be ______________.

6. *The stages in complete metamorphosis are* ______________

7. *The stages in incomplete metamorphosis are* ______________.

Homework

1. The worm in the apple is not really a worm but a larva of a certain moth. How do you think it got into the apple?
2. The larva is the most active stage of an insect's life. Why do you think that most insects lay their eggs near a food supply?
3. Which stage that you studied in class does a caterpillar most resemble? Why? Into what does it develop?
4. *Some insects, like the bees and ants, are known as social insects. Select one such insect and find out what special care is given to eggs or larvae to make sure that their life-spans are completed successfully.*

16. WHERE DO EMBRYOS OF ANIMALS DEVELOP?

Outcomes

- In most water-living animals, the eggs are fertilized after they are laid, and the embryo develops outside the body.
- In most land-living animals, the eggs are fertilized inside the female's body.
- Mammals, including man, are the only animals in which all embryos develop within the body of the female.
- *In mammals, the embryo is provided with food and oxygen by the mother's blood stream, until birth.*

Motivation

Display a jar containing the development of a frog (or a fish). Call the pupils' attention particularly to the size of a frog's egg which is readily visible. Tell the class that an elephant, at birth, weighs several hundred pounds but develops from a fertilized egg which is microscopic in size and much smaller than a frog's egg. Challenge the class to a possible explanation of this puzzle. (Do not, at this time, accept or reject any explanation.)

Development

1. a. Using the jar of specimens displayed in the motivation, elicit that most animals that live in water (fish, frog) lay their mature eggs in water. Ask, "How will these eggs be fertilized?" Pupils should be able to explain that the male animal releases the sperm near the eggs and the sperm will swim about until some fertilize the eggs. Identify this as ***external fertilization.***

   b. Guide the pupils to conclude that the embryo develops within the egg, outside the female's body.

2. a. Ask, "How can the sperm reach the eggs in animals that live on land?" Lead the class to an understanding that in such animals, sperm must be deposited by the male animal directly into the female's body. Then the sperm may swim about and fertilize the eggs. Identify this as ***internal fertilization.***

   b. Ask the class to name groups of animals in which fertilization must be internal. Insects, reptiles, birds, and mammals should be mentioned, since all of these groups are largely land-living organisms.

3. Display reptilian (turtle or snake) eggs and birds' eggs. Ask, "Why are these eggs so large?" Elicit from the pupils that since the embryos of these animals develop within the egg, they require large amounts of food, which they obtain from the egg. Show a bird embryo (12-1638).

4. a. By recalling pupils' own experiences with mammals (dogs, cats, etc.), establish the fact that these animals do not lay eggs.

   b. Display an embryo of a pig or rat (12-1648; 12-1658). Pupils should note the size of the embryo.

   NOTE: At this time, avoid technical structures and physiology in connection with the embryo.

5. Referring to the motivation in regard to the elephant, ask, "If the egg from which the embryo develops is microscopic, where does it

obtain its necessary food?" Lead the class to the understanding that the mother's blood provides the embryo's blood with digested food and oxygen, and removes its wastes also. (Refer to functions of the blood, taught in 8th grade.) Point out the similarity in human and all mammalian embryos.

6. *There are many people who say that a baby (embryo) is carried in the "stomach." Discuss with the class the fact that the female animal has a special organ, called the uterus, within which the embryos develop. (In the wall of the uterus, the embryo's circulatory system lies close to the mother's circulatory system.) It is here that the embryo's blood gets food and oxygen from the mother's blood and gives up its wastes.*

Summary

1. Where are eggs of fish and frogs fertilized? Why is this possible?
2. What kind of fertilization is internal fertilization?
3. In what kinds of animals does it occur? Why?
4. Why are the eggs of birds and reptiles so large?
5. Where do embryos of mammals develop?
6. *How is an embryo of a mammal fed?*

Homework

1. How does internal fertilization differ from external fertilization?
2. Select any 10 animals and fill in the information asked for in this chart:

NAME OF ANIMAL	FERTILIZATION (EXTERNAL OR INTERNAL)	EMBRYO DEVELOPS (INSIDE OR OUTSIDE BODY)
1.		
2.		
3.		
4.		
5.		
6.		
7.		

3. *Although fish lay eggs and fertilization is external, there are some exceptions. Select a fish that is a "live-bearer" and report on its life history.*

Materials

Life History of:

Frog (jar — 12-1618) (chart — 12-2678)	
Bird (jar — 12-1638) (chart — 12-2688)	
Pig (jar — 12-1648)	
Rat (jar — 12-1658)	Eggs of turtle or snake
Trout (jar — 12-1608)	Eggs of birds

◆

REINFORCEMENT AND REVIEW (12-16)

NOTE: It is left to the instructor to select the most suitable of the following suggestions for review and reinforcement.

Reading Selection

Read these paragraphs carefully and then answer the questions that follow:

Dr. Ernest E. Just (1883-1941), a Negro biologist, did important work in the study of cells and egg fertilization.

Born of middle-class parents in Charleston, South Carolina, he was graduated from Dartmouth College with honors and later taught at Howard University in Washington, D. C.

Dr. Just wrote two books and about 60 articles about his work and received many awards, including the famed Spingarn medal, which was presented to him by the NAACP in 1915. A year later he earned his doctor's degree from the University of Chicago.

In his later years, Dr. Just conducted research in marine biology for the U. S. Government in Woods Hole, Massachusetts.

Questions

1. In what biological studies did Dr. Just make important discoveries?
2. What kind of education did he have?
3. Which award did Dr. Just receive from the NAACP?
4. Where did he get his doctor's degree?
5. How did Dr. Just spend his later years?

Recommended Films (BAVI)

Fertilization (a microscopic study). 10 min.

Reproduction in Animals. 10 min.

Introducing the Reptiles. 12 min.

Insect Life Cycle. 10 min.

Worms to Wings. 13 min.

Life Cycle of the Frogs. 10 min.

Topics for Reports

1. Life History of the European Eel
2. Life History of the Sea Horse
3. Periods of Embryo Development (gestation) of Various Animals
4. The Effects of Radiation on the Development of Embryos
5. *Experiments to Duplicate the Work of Redi, Spallanzani, or Pasteur to Disprove the Theory of Spontaneous Generation.*

◆

17. HOW DID SCIENTISTS FIRST LEARN HOW CHARACTERISTICS ARE INHERITED?

LABORATORY LESSON

Outcomes

- Characteristics, or traits, are inherited in an orderly manner.
- The inheritance of some characteristics of an organism can be predicted.

- Heredity, or genetics, is the science that deals with how characteristics are inherited.

Development

1. Relate the beliefs concerning how characteristics were inherited prior to the work of Mendel. The common belief was that characteristics were acquired by the mixing of parents' "bloods" in the offspring. This belief implied that the characteristics of parents lost their identity by being mixed in the offspring similar to mixing paints in a bucket. Relate how Gregor Mendel, a 19th century Austrian monk, carried out his experiments in growing and studying pea plants. One of the characteristics or traits Mendel studied was the difference in height of the pea plant. He found that certain tall pea plants always produced tall offspring when self-pollinated. He also found that certain short pea plants always produced short offspring when self-pollinated. When he cross-pollinated tall plants with short plants, he always wound up with tall plants. But, when he took the tall plants which were produced through cross-pollination and self-pollinated them, he was quite surprised. The resulting plants were both short and tall, ¾ being tall and ¼ being short. The tallness trait had hidden the shortness trait when they were both present in the same plant. He found that these results were the same for other traits found in pea plants. Point out that his work led to the understanding of how characteristics are inherited. Identify Mendel as the father of the science of *heredity* or *genetics*.
2. Tell pupils they will now be faced with a problem similar to the one Mendel faced. Divide the class into groups and distribute materials to each group. Each group of pupils should get about 20-40 peas or beans.

Summary

Refer to questions on Worksheet to reinforce concepts.

(MAY BE DUPLICATED FOR USE BY PUPILS)

LABORATORY WORKSHEET — BIOLOGY: LESSON 17

Problem: How did scientists first learn how characteristics are inherited?

Materials

Package of dried peas, or
Package of dried beans with mixed-color seed coat
Sheet of white paper

Procedures and Observations

1. Pour the peas or beans out onto the white paper. Examine them carefully.
2. How many different traits can you find that vary from pea to pea or bean to bean? An example might be texture of the seed coat.
3. Fill out the chart, making careful observations of either the peas or beans with respect to each trait being studied.

TRAITS	PEAS OR BEANS
What differences in color were noted? (lighter or darker)	
What differences in size were able to be seen? (large or small)	
How were the shapes different? (round or oblong, flat or round, oblong or flat)	
What kind of texture did the seed coats have? (smooth, wrinkled, rough, dull, shiny)	

4. Choose one of the traits described on the chart. Sort either the beans or peas into groups with respect to differences in the trait.
5. Count the number of specimens in each group (the number of large peas, the number of small peas). How do your results compare with the results Mendel obtained in his studies of short and tall pea plants?

Conclusions

1. How can we account for the differences in the traits that were studied?
2. Did you discover any trait that showed no differences among the peas or beans studied? If we grew plants from these seeds and cross-pollinated them, how would the resulting offspring appear with respect to that trait?
3. Which traits studied might be hidden by a corresponding trait in the same plant?

Homework

1. List the characteristics or traits you share with one or both of your parents.
2. Do you know of any hidden traits that either of your parents have and which you also possess?

18. WHY ARE CHROMOSOMES IMPORTANT?

Outcomes

- Chromosomes are thread-like structures found in the nucleus of all cells.
- Chromosomes are composed of genes which are the determiners of inherited traits.

Motivation

Call 3 or 4 pupils with marked differences in height, weight, and eye color to the front of the room. Ask pupils to point out some of the characteristics, or traits, which vary among these pupils.

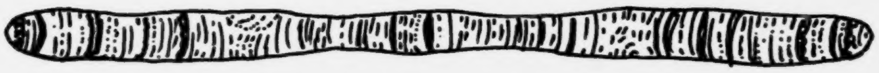
NOTE: Care should be taken to avoid situations that may cause embarrassment to pupils.

Elicit that heredity is responsible for many similarities and differences in characteristics of individuals. Ask, "Where are the factors that are responsible for these characteristics?"

Development

1. Exhibit a chart of the cell. Have pupils point out the chromosomes in the nucleus. What do chromosomes look like? Elicit that chromosomes are thread-like structures which appear during mitosis. Refer to previous learnings regarding binary fission. What happens to the chromosome number during fission? Elicit that each daughter cell receives an equal number of chromosomes from the parent. Point out that during all forms of reproduction the new individuals receive chromosomes from the parent or parents. Elicit that the chromosomes are the carriers of hereditary traits.

2. Use the diagram to prepare a chart or transparency and exhibit it to the class. Identify it as a section of a chromosome from a fruit fly. Point out that the bands on the chromosome correspond to the locations of the factors which are responsible for hereditary traits. Identify these factors as *genes*. How many traits can be carried by a chromosome? Elicit that chromosomes can carry thousands of traits. Many gene areas on human chromosomes have been identified as being responsible for specific traits.



Chromosome

3. Use a string of poppit beads, of various colors, to show the relationship between genes and chromosomes. Ask, "If the string of beans represents a chromosome, what do the beads represent?" Elicit that chromosomes are composed of chains of genes. Point out that genes are located at specific places on specific chromosomes.
4. Relate the work of Thomas Hunt Morgan who studied heredity in the fruit fly. Point out that the fruit fly is the most convenient laboratory animal in the study of heredity or genetics, since it completes its life cycle in only 14 days. How many generations of fruit flies can be studied in a year?
5. *Introduce the terms RNA (ribonucleic acid) and DNA (deoxyribonucleic acid). Point out that these molecules are responsible for gene action. DNA molecules are the building blocks of genes. Pupils can do research on DNA and RNA for homework.*

   NOTE: Do not go into DNA and RNA too deeply. Explain that it is studied in greater depth in high school Biology.

Summary

1. What are chromosomes?
2. What are the factors responsible for hereditary traits called?
3. Why are chromosomes called "carriers of hereditary traits"?
4. *Why is the fruit fly such an important laboratory animal in the study of* genetics? *Why is it possible to study many generations of fruit flies over a relatively short period of time?*

Homework

1. Write a report on Thomas Hunt Morgan's work in heredity in fruit flies. Many fine sources of information on this topic can be found in the library.
2. *Write a research paper on one of the following topics, using references which can be found in the library.*
   - *a. DNA — deoxyribonucleic acid*
   - *b. RNA — ribonucleic acid*
   - *c. The work of James D. Watson and Francis H. C. Crick in determining the structure of DNA.*

Materials

Chart of cell (S-I 12-1908)	String of poppit beads of different colors
Diagram of chromosome	

19. WHAT HAPPENS TO THE CHROMOSOMES WHEN EGG AND SPERM CELLS ARE PRODUCED?

Outcomes

- Egg and sperm cells are produced in the sex organs through a process called reduction division or meiosis.
- The sex cells are called male or female gametes.
- The gametes produced during reduction division or meiosis have ½ the number of chromosomes of the original cell.
- Fertilization restores the correct chromosome number to the new individual.

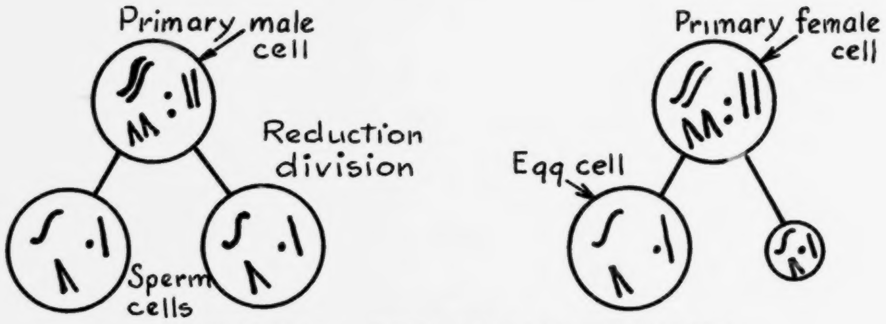
Motivation

Review the process of *mitosis.* All organisms of the same species have the same number of chromosomes in the nucleus. How many chromosomes are in the nucleus of a human cell? How is the chromosome number kept constant? Elicit that chromosomes duplicate themselves, prior to cell division, in order to insure that the chromosome number is kept constant.

What happens during fertilization? Elicit that the sperm cell combines with the egg cell to form a fertilized egg. If each parent cell has 46 chromosomes, how many chromosomes will there be in the fertilized egg? Elicit that there seems to be an apparent doubling of the chromosome number at fertilization. Have pupils offer possible means by which organisms overcome the apparent problem of doubling of chromosomes at fertilization.

Development

1. Elicit that there is a process, occurring prior to fertilization, in which the chromosome number is halved. Identify this process as ***reduction division*** or ***meiosis.***
2. Where are the sex cells formed? Elicit that the egg cell is formed in the ovary and the sperm in the testis. Identify the sperm as the ***male gamete*** and the egg as the ***female gamete***. Show, by means of the accompanying diagram, that the chromosome number is reduced by ½ during the formation of egg and sperm cells.

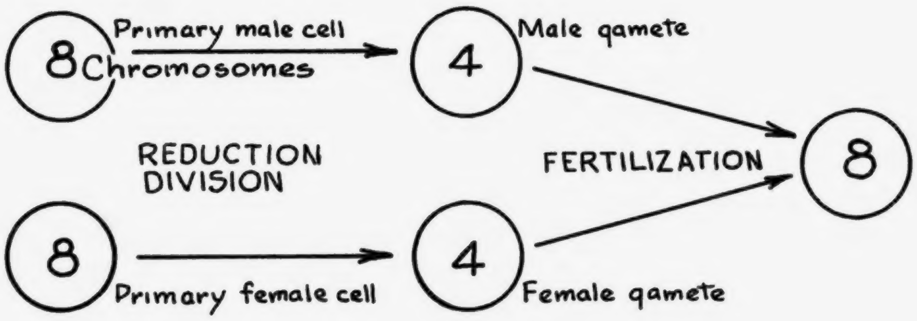


MEIOSIS or REDUCTION DIVISION

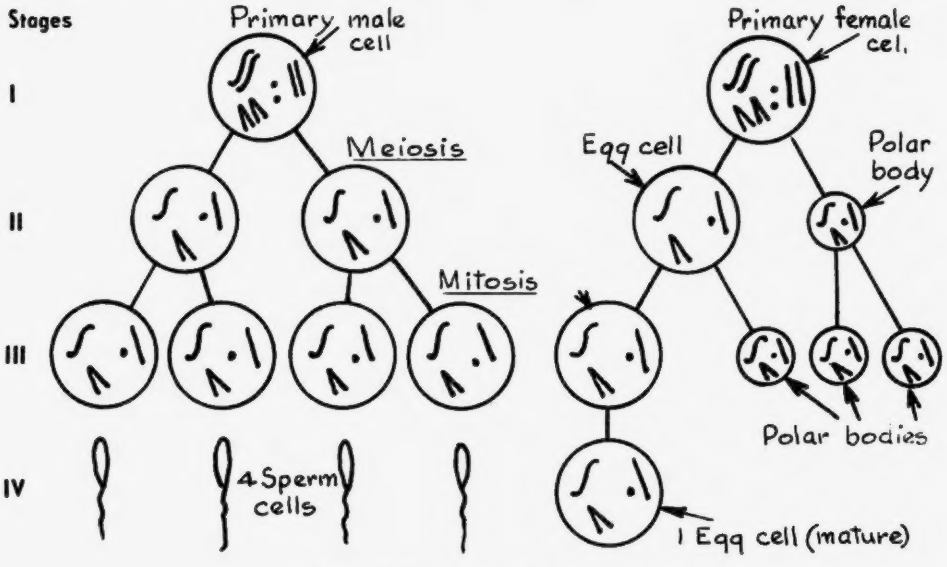
NOTE: Even though further steps are involved, this is enough to show that there is a reduction in chromosome number.

How many chromosomes are there in each of the primary cells? How are the chromosomes arranged? Elicit that there are 8 chromosomes arranged in 4 pairs. How many chromosomes are there in the egg and sperm cells? Elicit that each has 4 chromosomes, one from each pair.

3. What happens to the chromosome number at fertilization? Elicit that the original chromosome number is restored at fertilization.


8
Primary male cell
Chromosomes
4
Male gamete
REDUCTION DIVISION
FERTILIZATION
8
8
4
Primary female cell
Female gamete

4. *Meiosis or reduction division is only one step in the total process of* gametogenesis. *Elicit that gametogenesis is the process by which sex cells are produced. Reproduce the following chart and distribute it to the class.*


Stages
I
II
III
IV
Primary male cell
Meiosis
Mitosis
4 Sperm cells
Primary female cell
Egg cell
Polar body
Polar bodies
1 Egg cell (mature)

GAMETOGENESIS

How many sperms are produced by the primary male cell?

How many mature egg cells are produced by the primary female cell?

The primary male cell undergoes meiosis. What process do the 2 cells formed by meiosis undergo?

Identify the polar bodies as nonfunctioning egg cells.

Summary

1. How many chromosomes are there in a human egg or sperm cell?

2. What effect does reduction division have on the chromosome number of the sperm and egg cells?
3. How does fertilization restore the chromosome number?
4. *Compare the process of meiosis with the process of mitosis.*

Homework

1. Explain why the combined processes of meiosis and fertilization always result in chromosome number remaining constant?
2. Define fertilization in terms of male and female gametes.
3. *Why does a male produce many more active gametes than a female during gametogenesis?*

Materials

Duplicated chart of meiosis

Duplicated chart of gametogenesis

20. WHY DON'T ALL OFFSPRING LOOK EXACTLY LIKE THEIR PARENTS?

Outcomes

- Each trait has 2 factors or genes for determining that trait.
- If both genes are the same, the individual is called pure for that trait. If the genes are different, the individual is called hybrid for that trait.
- In hybrids, only one gene shows itself in the individual. This is called the dominant gene. The gene which does not show itself is the recessive gene.
- *Some factors or genes can be blended, in an individual, to produce a trait different from that produced by either gene.*

Motivation

Ask pupils if they have the same eye color as their parents. Why is it that blue-eyed children sometimes have brown-eyed parents? Elicit that the parents must have been carrying a hidden gene for blue eyes.

Development

1. Refer to Mendel's work with tall and short pea plants. How many factors or genes are responsible for determining height in a pea plant? Elicit that there are 2 factors or genes. One gene controls *tallness;* the other controls *short height.* Explain that scientists have labelled these genes, *T* - tall and *t* - short.

2. Point out that individuals receive 2 genes, for each trait, from the parents. These genes are located on a pair of chromosomes, one of the pair coming from the mother and the other from the father. If a pea plant has *TT* genes, will it be tall or short? If it has *tt* genes, will it be tall or short? Elicit that since there is only one kind of gene, the appearance will be a reflection of the character of the genes. Identify these individuals as being *pure* for the trait.

3. What will be the appearance of a pea plant with *Tt* genes? Elicit that the plant will be tall and that the gene for short height will be hidden. Identify this individual as being *hybrid* for this trait.

4. Point out that the gene which shows itself in hybrids is called the *dominant* gene. The gene which does not show itself is called the *recessive* gene. What is the dominant gene for eye color in humans? What is the recessive or hidden gene? Identify this study as the *Law of Dominance.* Other examples of dominant and recessive traits in humans are:

Dominant Trait	*Recessive Trait*
Free earlobe	Attached earlobe
Normal color vision	Color blindness
Curly (kinky) hair	Straight hair

5. Exhibit chart of Drosophila, Red Eye and White Eye (S-I 12-2148). Which color is dominant? Which is recessive? Elicit that red is dominant over white.

   NOTE: Do *not* bring out the fact that this trait is sex-linked.

   What would be the gene makeup for the following individuals?

   a. pure red-eyed b. pure white-eyed c. hybrid red-eyed

   NOTE: Refer to homework question #3 for additional discussion.

6. *Explain to pupils that not all traits follow the Law of Dominance.*

Exhibit the chart of Red and White Four O'Clock (12-2188). What is the gene makeup for the pure white four o'clock? What is the gene makeup for the pure red four o'clock? Why are pure red and pure white four o'clocks identified with the capital letters WW, RR? *What is the appearance of the offspring when pure white are crossed with pure red? Elicit that the factors are blended to give a pink variety. One color does not dominate the other. Identify this as* incomplete dominance *or* blending.

Summary

1. If one parent is pure for brown eyes and the other pure for blue eyes, what will be the color of the eyes of the offspring? What will be the gene makeup of the offspring?
2. What is the difference between an individual who is pure for brown eyes and one who is hybrid for brown eyes? What are the colors of their eyes?
3. *What are the differences between complete dominance and incomplete dominance?*

Homework

1. If a round seed coat in peas is dominant over a wrinkled seed coat, what is the gene makeup of the following individuals?
   a. pure round seed coat
   b. pure wrinkled seed coat
   c. hybrid round seed coat
2. What might happen if you were to cross two pea plants, both with hybrid round seed coat? (The gene makeup of the new individuals will vary.)
3. *Human skin color is the result of the blending of several sets of genes possessed by all humans. How does this prove the fact that all humans are members of one species?*

Materials

Chart of Drosophila, Red Eye and White Eye	(S-I 12-2148)
Chart of Red and White Four O'clocks	*(S-I 12-2188)*

21. HOW ARE GENES COMBINED IN OFFSPRING?

Outcomes

- Each parent contributes one gene to the offspring's pair of genes for each trait. The resultant gene makeup of the offspring is formed by the contribution of one gene from the male and one from the female.
- When hybrids are crossed, three out of every four of the offspring will show the dominant trait, while the remaining one will show the recessive trait.

Motivation

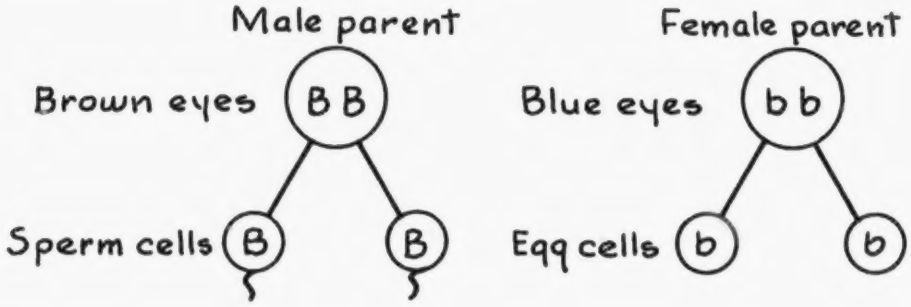
What is the gene makeup of the following individuals?

a. Pure brown-eyed human male (BB)
b. Pure blue-eyed human female (bb)

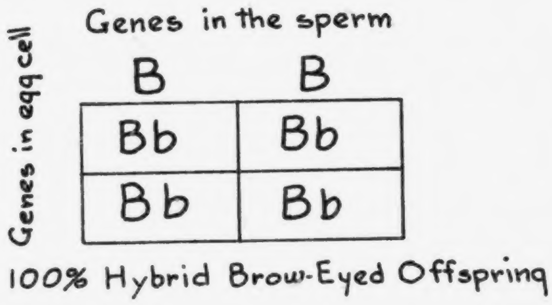
What is the gene makeup of the offspring? What is the actual color of the offspring's eyes? Elicit that all the offspring are hybrid brown eyes. How can we predict the probable gene makeup of the offspring of a cross between two hybrids?

Development

1. Refer pupils to the following diagram.



If a male parent is pure for brown eyes, what trait will be carried by the genes in the sperm cells he produces? Elicit that since the male has only genes for brown eyes, he can contribute only a brown-eyed gene to the sperm cells which he produces. What trait will be carried by the genes in the egg cells produced by a pure blue-eyed female?

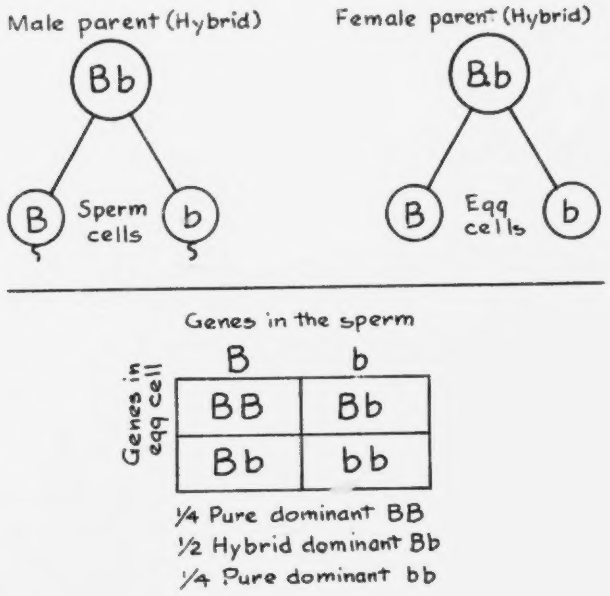

Genes in the sperm
Genes in egg cell
B
B
Bb
Bb
Bb
Bb
100% Hybrid Brow-Eyed Offspring

Introduce the pupils to the device used by geneticists to predict the possible gene makeup of offspring.

NOTE: It will not be necessary to identify the term Punnett square.

How are the genes of the parents represented in the diagram? Elicit that the parents' genes are placed on the outside of the square. What do the four boxes inside the square represent? Elicit that each box represents the possible gene makeup of each of the offspring. What is the gene makeup of the offspring? Elicit that they are all hybrid brown-eyed. Show how the resultant gene makeup of each offspring is related to that of both parents, and formed by the contribution of one gene from the male and one from the female.

2. Use the following chart to illustrate a cross between two hybrids.


Male parent (Hybrid)
Female parent (Hybrid)
Bb
Bb
B
Sperm cells
b
B
Egg cells
b
Genes in the sperm
Genes in egg cell
B
b
BB
Bb
Bb
bb
¼ Pure dominant BB
½ Hybrid dominant Bb
¼ Pure dominant bb

How many different kinds of genes can be contributed by each parent? Elicit that each parent can contribute either of two different genes. What is the resulting gene makeup of the offspring? Elicit that 2 out of 4 (50%) are hybrid brown-eyed, 1 out of 4 (25%) is pure brown-eyed and 1 out of 4 (25%) is pure blue-eyed. What portion of the offspring will have brown eyes? (75%).

3. ***Ask, "How can we tell if an individual is pure or hybrid for a trait?" Elicit that we cannot always tell the gene makeup of an individual by his outward appearance. In order to answer the question, have pupils solve the following problems:***
    a. ***Cross a hybrid brown-eyed individual with a pure blue-eyed individual.***
    b. ***Cross a pure brown-eyed individual with a pure blue-eyed individual. What is the gene makeup of the offspring in each cross? What is the actual color of the offspring's eyes? Elicit that in the cross with the pure brown-eyed (dominant) individual, all the offspring were hybrid for brown eyes and there were no blue-eyed individuals produced. In the cross with the hybrid brown-eyed individual, there will be blue-eyed individuals produced (50%). Identify this as a*** **back-cross.** ***If individuals with the recessive character result from the cross with a pure recessive, the parent with the unknown gene makeup must have been a hybrid.***

Summary

1. **What is the genetic makeup of the sperm produced by a hybrid red-eyed male fruit fly?**
2. **What is the resultant gene makeup of the offspring of a cross between 2 pea plants, one hybrid for round seeds and the other pure for wrinkled seeds?**

    NOTE: Round seed coat is dominant over wrinkled coat.
3. ***The results of several crosses between yellow peas, with the same gene makeup, and green peas, with the same gene makeup, show 9,020 peas with a yellow coat and 3,005 peas with a green coat.***
    a. ***What was the probable gene makeup of the parents?***
    b. ***What is the dominant color?***

Homework

1. What are the results of the following crosses?

   NOTE: Tall is dominant over short.

   a. Pure short pea plant x pure short pea plant.

   b. Pure short pea plant x hybrid tall pea plant.

   c. Pure tall pea plant x hybrid tall pea plant.

2. Why are the plants represented as *Tt, TT,* or *tt,* but the sperm as *T or t?*

3. *If a hybrid tall plant is self-pollinated, what is the gene makeup of the offspring? What is the appearance of the offspring?*

Materials

Duplicate of charts used in the lesson

◆

REINFORCEMENT AND REVIEW (17-21)

The teacher may select one or more of the following suggestions for review and reinforcement.

Topics for Reports

The teacher should give pupils directions in locating sources of information in the field of genetics.

CONTRIBUTIONS OF SCIENTISTS

Thomas Hunt Morgan
Herman J. Muller
Karl Erich Correns
Hugo DeVries
Walter S. Sutton

TOPICS

1. What Are Mutations?
2. How Do Mutations Occur?
3. What Is the Science Cytogenetics?
4. Why Are Fruit Flies (Drosophila) Called the Key to Heredity?

5. What Is a Genetic Map?
6. What Is the Cause of Sickle-cell Anemia?
7. *What Is the Relationship Between DNA and Chromosomes?*

Audio-Visual Materials

FILMS (16 mm) (on approved list — BAVI)

Gene Action. 247.61 (Enrichment)
Replication of DNA of chromosomes during mitosis.

Human Heredity. 300.99
Basic information regarding human genetics and the social implications. Correction of many prevalent misconceptions.

Laws of Heredity. 343.4
Demonstrates the mechanisms by which hereditary characteristics are transferred from one generation to the next.

SINGLE CONCEPT FILMS. (8 mm)

Drosophila: Crossing. 890.112
Shows procedures and techniques in making simple crosses.

Neurospora Techniques, Part II. 968.311 (Enrichment)
A study of neurospora to show genetic segregation.

FILMSTRIP

Fruit Fly Key to Heredity. 38755.20 (Enrichment)
Laws of heredity demonstrated with the fruit fly.

TRANSPARENCIES

Principle of Segregation. 7212.859

Meiosis and Crossing. 7212.861

Mitosis and Meiosis Compared. 8291.9

Reading Comprehension

Read the paragraphs carefully and then answer the questions which follow.

When Gregor Mendel, the Austrian monk, attempted to solve the mysteries of heredity one hundred years ago, he studied garden peas. He did not know about chromosomes and genes, but he kept careful records of such factors as height, color of flower, and color and condition of seed coats.

Later geneticists worked with the fruit fly (Drosophila) and mice because they breed very often. Consequently, many generations could be studied in a short time. Also, many offspring are produced rapidly, making it possible to test and prove the theories and principles which all scientists are constantly seeking.

It is not so easy when it comes to understanding heredity in humans. However, the principles and theories developed from the study of simple plants and animals have helped us to understand why and how we resemble, and, at the same time, differ from each of our parents and our brothers or sisters. For instance, geneticists believe that skin color in humans is determined by at least six pairs of genes. These control the amount of melanin found in the skin. Melanin is a skin pigment which is found in all races of mankind. The shade of the skin is determined by the chance combination of all of these six pairs of genes.

As you know, people of all races, when exposed to the sun, get darker, because the body can temporarily produce more melanin to protect us from the harmful effects of too much sunlight. The only exception is the hereditary condition called albinism, where the necessary combination of genes for producing melanin are absent. Albinism is a condition found in all races of man, as well as in some animals.

QUESTIONS

1. Why is Gregor Mendel considered "The Father of Genetics"?
2. Why were garden peas, fruit flies, and mice chosen for laboratory heredity studies?
3. Name three traits which Gregor Mendel studied.
4. What is melanin?
5. Name 3 ways in which you differ from your brother.
6. Explain why there are so many shades of skin color among the peoples of the world.

7. Melanin is found in the skin of: (a) all races (b) Negro race (c) Melanesians__________.

8. When the proper gene combinations for the production of melanin are absent, the condition is known as__________.

9. Albinism can be found in (a) Negroids (b) all races (c) Melanesians.

10. Why do people (regardless of race) get darker when exposed to sunlight?

◆

HEREDITY

Suggested Lessons and Procedures

22. HOW IS SEX INHERITED?

Outcomes

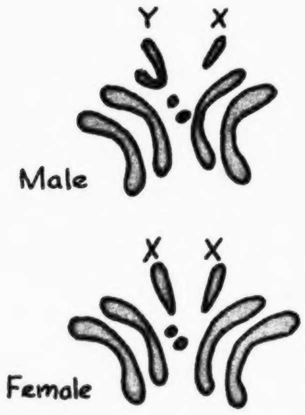
- One pair of chromosomes in many animals, including man, are not alike. These chromosomes, called X and Y, determine sex.
- All egg cells contain only the X chromosome.
- 50% of the sperm cells contain an X chromosome. The other 50% of the sperm cells contain the Y chromosome.
- An egg cell fertilized by a sperm having an X chromosome will be a female. An egg cell fertilzed by a sperm having a Y chromosome will be a male.
- *Traits that are inherited along with sex are called sex-linked characteristics*

Motivation

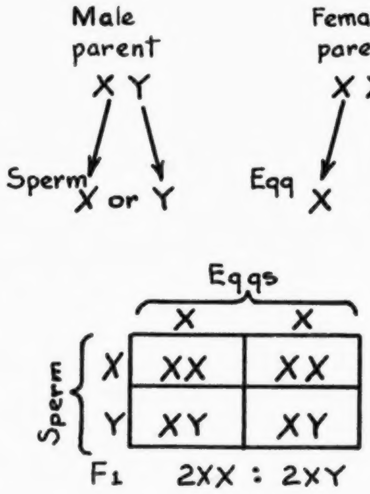
Tell the class that statistics show that in the United States, or any other large nation, the ratio of male and female individuals is approximately 50-50. How can this be explained?

Development

1. Reproduce diagrams for distribution to pupils. (See next page.)
2. a. Have the class study the chromosome configuration of the fruit fly. (Make sure that pupils know that these are not actual



The four pairs of chromosomes in a fruit fly



	X	X
X	XX	XX
Y	XY	XY

photographs.) Ask, "What differences do you note between the pairs of chromosomes in the male and female?"

b. Point out that even though humans have 23 pairs of chromosomes, the appearance of chromosomes is similar. This is true of most organisms.

c. Tell the children that these so-called X and Y chromosomes determine the sex of the organism.

3. a. After studying the diagram with the Punnett square, elicit from the class that when the female produces eggs, each egg contains an X chromosome. Then ask, "Are all the sperm cells alike? If not, how many kinds of sperm cells are produced? If 100 sperm cells are made, how many will have the X chromosome? How many will have the Y chromosome?"

b. Now examine the Punnett squares and analyze each possible combination that might result during fertilization. The class should note that two of the offspring have double X chromosomes and that these will be females. Likewise, two of the offspring each have a combination of XY chromosomes, making them males.

c. Have the class express this in terms of percentage (50% female, 50% male).

d. From the above observation, elicit the fact that it is the sperm that determines the sex of an organism.

4. *With the help of a chart (12-2228), point out that the gene for*

color-blindness, which is a recessive trait, is carried only by the X chromosome. Identify such a trait as a sex-linked character. Since the Y chromosome does not have such a gene, when fertilization occurs and a male is produced, he will be color-blind. For a female to be color-blind, both of the X chromosomes would have to contain this recessive gene. This is not likely to happen often, according to Mendel's Law of Dominance. (Use Punnett squares to illustrate this fact.)

Summary

1. In what way do egg cells and sperm cells differ as far as chromosomes are concerned?
2. According to the Punnett squares, what are the chances that a female or a male will be produced during fertilization? Explain your answer.
3. A codfish lays about a million eggs. If all of them are fertilized and develop into fish, how many, approximately, would be males? How many would be females? Explain.
4. *What is meant by sex-linked characteristics? Give examples.*

Homework

1. If all the sperm cells had either an X or a Y chromosome, what would be the sex of the offspring? Why?
2. If you were able to examine sperm cells under a microscope and see their chromosomes, how could you tell which sperm would produce a female and which would produce a male during fertilization?
3. A cat gave birth to 5 kittens. All turned out to be male kittens. How can you explain this?
4. *As you learned, color blindness is carried only by the X chromosome. Explain why more men suffer from this disease than women.*

Materials

Reproduced diagrams (See Development)

Sex-linkage charts: color blindness (12-2228); hemophilia (12-2238)

23. HOW MAY THE DEVELOPMENT OF A TRAIT BE AFFECTED BY THE ENVIRONMENT?

LABORATORY LESSON

Outcomes

- In the development of each living thing, both heredity and environment (surroundings) are equally important.
- If some conditions in the environment change, some of the traits in the organism may not develop properly.
- The changes in development caused by a changed environment do not affect the genes themselves.
- *Living things may develop normally again, if conditions in the environment return to normal.*

Development

1. Explain to the class that both heredity and environment are equally important in the development of all living things. Each trait must have certain conditions if it is to help the plant or animal to live successfully.
2. Several days in advance of this lesson:
   Soak some fast-growing seeds (corn, wheat, oat, or radish) in water overnight and plant them in soil in two pots or cigar boxes. Keep them in total darkness until the leaves have begun to develop. Then transfer one container to light, leaving the other in darkness. In a few days, there should be a marked difference in their appearance. The ones in light will be a healthy green, while those remaining in the dark will be white or a pale yellow.

   NOTE: This could be started after Lesson 21 (during Review and Reinforcement) with a weekend intervening. Or, students may start the experiment at home and bring the results to class.
3. Distribute to each group a container kept in light and one kept in darkness. Have as many of such pairs of containers as there are experimental groups.

LABORATORY WORKSHEET—BIOLOGY: LESSON 23

Problem: How may the development of a trait be affected by the environment (surroundings)?

Materials

Container with seedlings growing in light
Container with seedlings growing in the dark

Procedures and Observations

1. Study the plants that are growing in the two containers. What is the chief difference in the appearance of the two sets of plants? __________.

   Compare your observations with the observations of other groups in your class. __________.

2. Are there any other differences that you see besides a color difference? __________. If you do, write down what these differences are. __________

   ____

3. In 7th grade science, you learned that the green color in plants is called chlorophyll. Each cell in a green leaf has genes that control the production of chlorophyll. Do you think that someone removed these genes from the plants growing in the dark? __________.

   What was the only difference in the environment between the two groups of plants? __________.

   What do you think the genes controlling the production of chlorophyll need in order to do their job? __________.

4. *If you want to prove that the pale plants that grew in the dark still have the genes for making chlorophyll, where would you put them?* __________. *Do this, and see what changes take place in the plants from day to day.*

5. How does today's equipment show that differences in the environment may decide how a trait develops? __________.

6. *Continue keeping some of the pale plants in the dark. What eventually happens to them? Why?*

Conclusions

1. If living things are to develop properly, both heredity and __________ are important.

2. In the absence of light, ____________ cannot be made by plants.

3. Certain parts in the chromosomes called ____________ control the production of chlorophyll.

4. The absence of light (changes, does not change) __________ the genes.

5. This means that changes in the environment may control how a trait ____________ not the trait itself.

6. *If conditions for growth become normal again, the trait may develop ____________.*

Homework

1. If you stand under a large tree, you will find very little grass growing there. How can you explain this?
2. Immigrants who came to the United States years ago were much shorter than their children who grew up here. What differences in the environments of the parents and their children do you think are responsible for this?
3. Were the genes for tallness or shortness affected by the environment? Explain.
4. *As an experiment, a biologist cut off the tails of mice and mated the mice. All their offspring were born with tails. He did the same for several generations. Each time, the offspring were born with tails. Using the knowledge you gained in today's lesson, explain these results.*

24. HOW DO SCIENTISTS USE HEREDITY TO IMPROVE PLANTS AND ANIMALS?

Outcomes

- By selecting plants or animals that have the desired traits and breeding them, more such living things may be produced.
- Further selection and breeding are needed so that *all* the organisms show the desired trait.
- It is easier to control man's environment than his heredity. There-

fore, the best way to improve the human race is to improve his environment.

- ***A useful mutation may serve to establish a variety of a plant or an animal.***

Motivation

Tell the story of the shorthorn breed of cattle that was excellent for beef but was susceptible to heat and disease. A long-horned breed of cattle (Brahman) that produced poor beef but was not bothered by heat or disease was imported from India and crossed with the Texas cattle. The offspring were excellent beef cattle with the ability to resist heat and disease. We call this animal the Texas Longhorn.

Development

1. a. With the help of a chart (12-2268), pictures, and by referring to previous learnings (Lessons 17, 20), develop the principle that hybridization is used in establishing a variety of plant or animal having a desired trait.
    b. Pose the problem: Suppose you were a farmer growing corn, and you found a few plants which were taller and produced more and better ears of corn than the rest. What would you do to develop a full crop of such plants?
2. The following steps should be elicited from the class:
    a. Seed corn should be selected from the tall corn and planted for the next crop.
    b. Recalling that seeds result from pollination and fertilization, pupils should suggest artificial pollination using the pollen only from tall plants to pollinate the flowers of other tall corn plants. At this point, ask, "What shall we do with the short plants that some of the planted seeds produced?" (They should not be used for pollination.) Identify the above procedures as *selection.*
    c. Once again, the seeds from the mature, tall corn plants should be selected and the same procedures followed as above. Identify this step as *inbreeding.*
    d. If this process is repeated through several generations, a variety

of tall and very productive corn will be established. Ask, "Were the traits that were established dominant or recessive? How do you know?" (Refer to Lessons 20 and 21.)

   e. In a similar way, many varieties of plants and animals were produced. Some that should be mentioned are: Hereford cattle, racing horses, small turkeys, pigeons, winter wheat, fruits such as plumcot, etc.

3. By referring to lessons on asexual reproduction among plants, have the class recall that parts of plants are often used to grow new plants having desired traits. Examples: seedless oranges, potatoes, strawberries, etc. This method continues the desired traits without change.

4. *Sometimes an organism appears showing a sudden change in a trait (short-legged sheep, for example) which may be useful. Direct the class to the conclusion that using the techniques of hybridization (Lesson 21), selection, and inbreeding, a short-legged variety of sheep has been established. (Of what value is it?) Identify sudden changes in the genes as* mutations.

   Elicit some other possible examples of useful mutations which have or could be established.

5. a. Ask, "Can we easily use the methods we learned about today to improve mankind?" Lead the pupils to understand that humans cannot be treated as plants and animals. "How, then, can we improve man's development?" The class should realize that the best way of achieving this goal is to improve man's environment (education, housing, food, etc.).

   b. Identify this procedure as euthenics.

Summary

1. How does man use the process of selection to improve plants and animals?
2. What is meant by inbreeding?
3. How can parts of certain plants be used to preserve some desired trait for future generations?
4. Why is it not practical to improve mankind through selection and breeding?

5. How can mankind be improved?
6. *How can a useful mutation be established?*

Homework

1. Imagine that you owned a farm and you raised chickens to sell the eggs. You found that a few of the chickens laid many more eggs than others. Describe what you would do to establish a variety of chickens that were excellent egg producers.
2. Name 3 plants and 3 animals that were developed because they had certain desirable traits. After each, mention the trait.
3. If you were asked to make a plan to improve the development of the people in your community, what would you include in your plans?
4. *In most states, before a couple may marry, they must take a blood test.*
    - *a. Find out why this blood test is given.*
    - *b. Does this help to improve the community? How?*

Materials

Chart (12-2268) (breeding of hybrid corn)
Pictures of varieties of plants and animals bred for desired traits (cattle, fowl, fruit, etc.)

25. HOW DO CHROMOSOMES AND GENES CAUSE INDIVIDUAL DIFFERENCES AS WELL AS SIMILARITIES IN HUMANS?

Outcomes

- All humans, regardless of how they seem to differ, belong to the same species and are derived from common ancestors.
- Scientists sometime speak of three main racial groups: Caucasoid, Mongoloid, and Negroid, based upon a few visible differences.
- Chromosome and gene combinations result in a great number of

variations in numerous characteristics even in the same group, making it difficult to draw a definite line between each group.

- There are far more traits common to all people, regardless of race, than the number of traits in which people differ.
- There is no scientific proof of a general superiority or inferiority of one group over another.

Motivation

Ask class to assume the role of a new-car buyer. The teacher, as salesman, suggests two options for each item such as: number of cylinders, number of doors, body style, whitewall tires, air conditioning, horsepower of motor, radio, color, etc. Using the items listed, ask, "How many different cars would we get if each buyer made up his mind independently regarding each option?" Elicit that by different combinations of choices, a wide variety of types are possible for each car.

Development

1. Elicit the analogy of the above to chromosome and gene combinations from each parent, making possible the great variety in offspring. Ask, "What are the possibilities of getting two people exactly alike? How do you differ from your brother? Are twins alike?"
2. Demonstrate similarities and differences among pupils by measuring, recording, and comparing such factors as:

   a. height
   b. shoe size
   c. color of eyes
   d. color of skin
   e. rate of heartbeat
   f. respiration rate

   Elicit the concept that even within the same racial group there is great variety in traits and characteristics.
3. Develop concept of the vast number of similarities common to all groups by eliciting examples, such as blood groups (interracial blood transfusions are now a common practice) and internal organs (transplantation of the heart from a Negro into Dr. Bleiberg, a Caucasian), etc. Stress the idea that there exists a vast number of similarities among the groups.
   Behavioral similarities of all people can be brought out by such questions as "How do we react to:

a. an unexpected loud noise?
b. a thrust at the eye?
c. the odor of food when we are hungry?
d. someone yawning nearby?"

"Which of these make you feel warm? Cool?" (red, light blue, light green, orange)

Mention fossil evidence to elicit the reasoning behind the theory of the common ancestry of all ethnic groups, and note that all groups are, scientifically, one biological species, Homo sapiens.

4. Display photographs of prominent individuals of different races in the fields of:

    a. sports
    b. music
    c. sciences
    d. politics
    e. show business
    f. armed forces
    g. religion
    h. civil rights
    i. government, etc.

    Elicit that ability and potential capabilities are found in all groups.

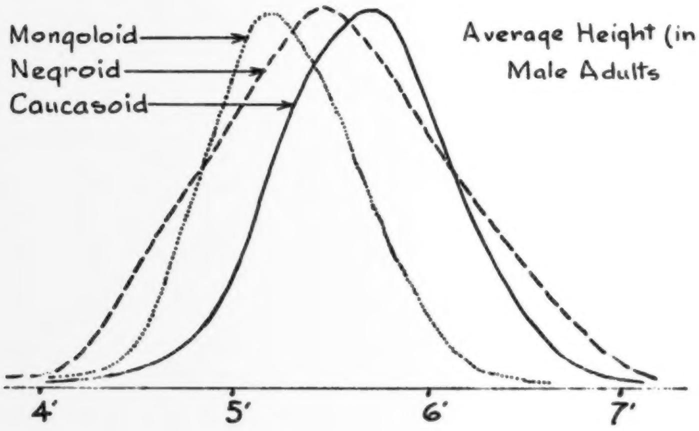
Summary

1. What is the scientific name of the species to which all humans belong?
2. What are the three major groups into which scientists try to divide humans?
3. What causes variations within each group?
4. Why is it difficult to draw definite and distinct lines to separate each of the races?
5. How do the number of similar traits and characteristics compare with the number of dissimilar characteristics?
6. Outstanding individuals in different fields can be found in all of the races.
7. Can superiority of one individual over another with respect to *one particular trait* be demonstrated?

Homework

1. "Differences among individuals in any one trait within a race are

often greater than the average difference between races or population groups." The quotation is from a UNESCO report by a group of scientists. Would a comparison from this graph illustrate the statement? Explain in your own words.



2. **Explain why the fact that each individual has two parents makes for a great variety in traits in humans.**

3. **If all humans had the same skin color, how would you, as a scientist, divide Homo sapiens into races?**

4. **How do chromosome and gene combinations make possible:**

    a. baby identification in hospitals

    b. criminal investigation? (fingerprints, footprints, bloodhounds)

5. **Tell how chromosome and gene combinations are like a deck of cards in respect to variety of individuals that are born and the variety of card hands that are dealt.**

6. **Report on the work of Dr. Louis Leaky in the Olduvai Gorge in Africa in his search for the history of Homo sapiens.**

Materials

Photographs of prominent people of different races

Photographs of anthropological, archeological, and paleontological significance

◆

REINFORCEMENT AND REVIEW (22-25)

Reading Exercise

Read these paragraphs carefully and then answer the questions which follow them.

BROTHERS UNDER THE SKIN

In the 18th century, Linnaeus, a biologist, undertook to classify living things according to their similar characteristics. Such a group of organisms is called a *species.* Some examples of a species are dogs, cats, and humans.

Although there are differences among individuals in the species, there are many more similarities. For example, in the species that includes all races of man, there are a few differences, like color of the skin or the shape of the eyes, but these are minor differences. All members of this species, regardless of race, are basically similar. They are built the same way, perform the same functions, have the same abilities, and have the same needs.

Sometimes people behave differently because the environment in which they develop is different from someone else's. (Do you remember the experiment you did with plants to show that a change in the environment affects the way genes develop?) This doesn't happen because they are inferior people. Studies show that in a good environment, most people will develop their abilities in the same way and will become successful according to these abilities.

Scientists have also found that each race of the human species has its share of very capable people, its share of average people, and its share of below-average individuals.

When scientists investigated how the races of mankind originated, they discovered evidence showing that all races probably had a common ancestor who lived a million or more years ago.

With all this evidence to show the many and important likenesses among different kinds of people, it can truly be said that "We are all brothers under the skin."

QUESTIONS

1. What is a species? Give several examples.
2. Why are all races of mankind placed in the same species?
3. How do the differences between people compare with their similarities?
4. Why do many people behave differently from other people?
5. Would it be correct to say that one group of people is better than another? What sentence in this article would you select to explain it?
6. What did scientists discover about the ancestor of mankind?
7. In your own words, explain the meaning of the title of this article.

Films (BAVI)

Brotherhood of Man. 11 min. Color.

Highlights the anthropological approach to understanding in intergroup relations; man's mental ability is inherent in every ethnic group. (This film is particularly relevant to the reading exercise and is recommended for the junior high school pupil.)

RECOMMENDED FOR ENRICHMENT

Heredity and Environment. 11 min.

An overview of cultural inheritance, genetics, environmental influences, and their interrelationship.

Heredity and the Chromosomes. 30 min. Color.

Theory of genes and chromosomes.

Heredity in Animals. 9 min.

Explains Mendelian Laws.

Genetics — Improving Plants and Animals. 14 min.

Test

From the list, select the correct word to complete each statement.

hybrid
dominant
recessive
species

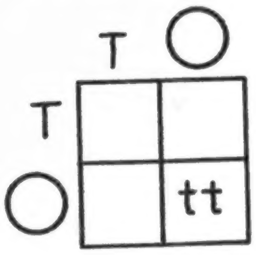
genes
environment
X and Y chromosomes

inbreeding
heredity
100%
75%

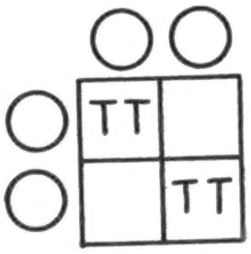
1. ____________ must be good so that traits develop properly.
2. A ____________ is the offspring of a cross between pure dominant and recessive parents.
3. The sex of an organism is determined by the ____________.
4. Breeders select plants or animals that are closely related for ____________ of the desired traits.
5. All races of mankind belong to the same ____________.
6. ____________ control the inheritance of traits.
7. ________% of the offspring will be hybrid when a pure dominant is crossed with a recessive.
8. ____________ is used to describe traits that are hidden by dominant ones, like shortness in pea plants.
9. ____________ is the transmission of traits from generation to generation.
10. There are many more brown-eyed people than blue-eyed, therefore, the ____________ trait is brown.

Completion

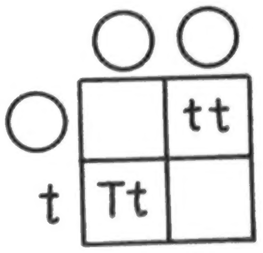
Fill in the missing information in the squares and circles.



A.______ % tall



B.______ % tall



C. ______ % tall

◆

BIOLOGY UNIT REVIEW

The material that follows includes suggested types of questions and content designed to offer the teacher guidelines for review and testing purposes. They are based on the desired outcomes delineated in the preceding lessons.

Multiple Choice

1. A cell divides to form new cells by a process know as
   a. photosynthesis
   b. fertilization
   c. mitosis
   d. pollination
2. As a result of spore formation, the chances for an organism to survive unfavorable conditions
   a. is increased
   b. is decreased
   c. remains the same
   d. increases and decreases
3. If a normal cell that contains 24 chromosomes divides, each new cell will receive
   a. 48 chromosomes
   b. 24 chromosomes
   c. 12 chromosomes
   d. one cell will receive 24, the other cell none
4. Most single-celled organisms reproduce by dividing in half. This is not true of
   a. bacteria
   b. ameba
   c. paramecia
   d. yeast
5. A starfish may replace a lost arm by means of
   a. regeneration
   b. grafting
   c. runners
   d. sexual reproduction
6. Tulips may be grown from structures called
   a. cuttings
   b. bulbs
   c. runners
   d. tubers
7. Normally growing yeast plants reproduce by
   a. regeneration
   b. sexual reproduction
   c. fission
   d. budding

8. The part of the cell which is most important in the process of reproduction is the

a. nucleus	c. cell membrane
b. cytoplasm	d. cell vacuole

9. In which of the following organisms will the genetic makeup remain unchanged when reproduction occurs?

a. frog	c. ameba
b. insects	d. fish

10. Bacteria are useful to man; they serve to

a. flavor foods	c. destroy weeds
b. produce oxygen	d. manufacture food

Completion

Fill in the missing word or words.

1. The nuclei of an egg cell and a sperm cell unite during the process of __________.
2. What the pollen grain is to plants, the __________ is to animals.
3. Plants are helped by insects carrying __________ from flower to flower.
4. Fertilization in a flower takes place in the part of the pistil called __________.
5. The fertilized ovule develops into __________.
6. A young plant within the seed is called __________.
7. Any part of a plant that contains seeds is the __________.
8. Most water-living organisms have their eggs fertilized in water. This is known as __________ fertilization.
9. In appearance, the early stages of the developing embryos of most animals look __________.
10. Egg cells are larger than sperm cells because they contain __________.
11. The only group of animals where the embryo develops within the female's body is the __________.

12. In such animals, the embryo gets its nourishment from ____________.

13. A sperm cell is provided with ____________ to enable it to reach the egg cell.

14. The worm-like stage in the life histories of many insects is the ____________.

True - False

Some of these statements are true and some are false. In the space in front of each statement, write *True* if it is true. If it is false, write the word in this space which will make it true.

_____ 1. Most fish reproduce by having external fertilization and external development of the embryo.

_____ 2. Some of the fruits we enjoy today originated in foreign countries.

_____ 3. The anther produces sperm cells in animals.

_____ 4. After a sperm and egg unite, growth results through the process of mitosis.

_____ 5. If the body cells of a fruit fly have 8 chromosomes, its sex cells will contain 8 chromosomes.

_____ 6. The changes that take place following the fertilization of a frog's egg up until adulthood are known as metamorphosis.

_____ 7. The sex of an offspring in sexual reproduction is determined by the female organism.

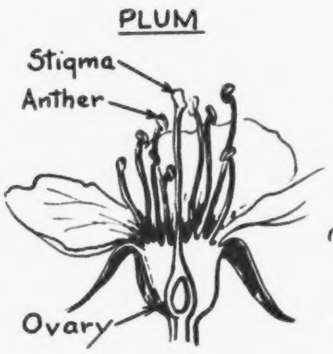
_____ 8. Genes are structures in the chromosomes that control our environment.

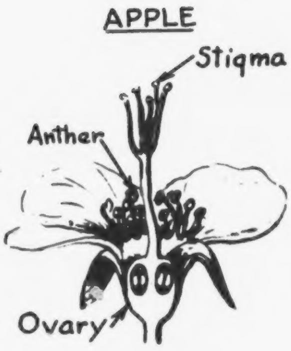
_____ 9. In most organisms an unfertilized egg will develop into a normal adult.

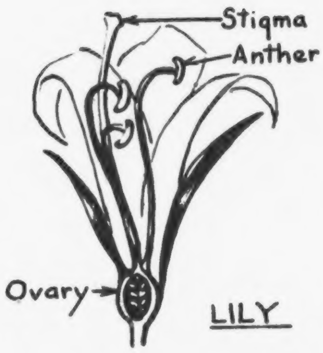
_____10. Both heredity and environment are important in the development of organisms.

Observation

Study the diagrams then answer the questions which follow.







1. What are the structures inside the ovary?
2. How can you predict that the plum will have only one seed?
3. What happens to the ovary after fertilization?
4. Which of the plants will likely have the largest number of seeds produced?
5. On which part do the pollen grains land?

Matching

In front of the words in Column A, write the letter from Column B to which the statement is most closely related.

A	B
_____1. genes	a. two sets of chromosomes
_____2. recessive trait	b. shortness in peas
_____3. dominant trait	c. located in chromosomes
_____4. fertilized egg	d. one set of chromosomes
_____5. sperm	e. germinating seed
	f. can be seen in a hybrid

Reading Comprehension

Read the paragraph carefully and then answer the questions following it.

> A geneticist first crossed a pea plant, pure for green pods (GG), with a pea plant, pure for yellow pods (gg). He then crossed two of the resulting offspring.

1. What is the dominant color for pea pods?

2. If the first cross produced 4 new plants, how many of these plants would you expect to be hybrids?
3. If the cross of the resulting offspring also produced 4 new plants, how many of these would you expect to be hybrids?
4. How many of the plants, in question 3, would you expect to have green pods?
5. How many of the plants, in question 3, would you expect to have yellow pods?

◆

SUGGESTED REFERENCES: BIOLOGY

For Teachers

BARZUN, JACQUES. *Race: A Study in Superstition.* New York: Harper and Row, 1965.

BENEDICT, RUTH. *Race: Science and Politics*, rev. ed. New York: Viking, 1959.

Biological Sciences Curriculum Study. *Teachers' Edition of Biological Science: Molecules to Man.* Boston: Houghton Mifflin, 1968. (Blue version.)

BONNER, DAVID M. *Heredity.* Englewood Cliffs, N. J.: Prentice-Hall, 1961.

COMAS, JUAN. *Racial Myths.* New York: UNESCO, 1965.

DOBZHANSKY, THEODOSIUS. *Heredity and the Nature of Man.* New York: Harcourt, Brace and World, 1964.

——. *Mankind Evolving: The Evolution of the Human Species.* New Haven: Yale University Press, 1962.

DODGE, RUTH. *Elements of Biology.* Boston: Allyn and Bacon, 1959.

DUNN, L. C. *Race and Biology.* New York: UNESCO, 1965.

GOLDSTEIN, PHILIP. *Genetics Is Easy.* New York: Compass, 1961.

LASKER, GABRIEL. *Human Evolution, Physical Anthropology and the Origin of Man.* New York: Holt, Rinehart & Winston, 1963.

LEVINE, ROBERT. *Genetics.* New York: Holt, Rinehart & Winston, 1965.

MONTAGU, ASHLEY. *Human Heredity.* New York: World, 1959.

MORHOLT, EVELYN, AND OTHERS. *A Sourcebook for Biological Sciences.* New York: Harcourt, Brace, 1958.

OTTO, JAMES AND TOWLE, ALBERT. *Modern Biology.* New York: Holt, Rinehart & Winston, 1963.

SIMPSON, G. E. AND YINGER, J. N. *Racial and Cultural Minorities.* New York: Harper and Row, 1965.

SMALLWOOD, WILLIAM AND GREEN, EDNA. *Biology.* Morristown, N. J.: Silver Burdett, 1968.

SUTTON, H. E. *An Introduction to Human Genetics.* New York: Holt, Rinehart & Winston, 1965.

For Pupils

ADAMS, R. L. *Great Negroes, Past and Present.* New York: Afro-American, 1964.

ASIMOV, ISAAC. *The Genetic Code.* New York: Signet, 1964.

DODGE, RUTH A. *Elements of Biology.* Boston: Allyn and Bacon, 1959.

GOLDSTEIN, PHILIP. *Genetics Is Easy.* New York: Viking, 1961.

KAHN, PAUL, AND OTHERS. *Investigating Science 9.* Singer, 1967.

OTTO, JAMES AND TOWLE, ALBERT. *Modern Biology.* New York: Holt, Rinehart & Winston, 1963.

PLOSKI, HARRY A. AND BROWN, ROSCOE C., eds. *Negro Almanac.* New York: Bellwether, 1967.

THURBER, WALTER A. AND KILBURN, ROBERT E. *Exploring Life Science.* Boston: Allyn and Bacon, 1966.

SCHEINFELD, AMRAM. *Why You Are You.* New York: Abelard-Schuman, 1958.

SCHNEIDER, HERMAN AND NINA. *Science in Our World. Book 5.* New York: Heath, 1965.